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13. ABSTRACT *(Maximum 200 words)*
A compilation of Life Cycle Cost (LCC) methodologies and techniques that will lead an inexperienced "coster" (one who estmates cost) step by step to devise a Rough Order of Magnitude (ROM) LCC estimate. The inexperienced coster is shown where and how to begin. The space arena was chosen to illustrate the methodologies by estimating theoretical examples. The LCC estimates presented illustrate space systems, but the same methodologies can be used with conventional ground or airborne systems. The examples portray only a top-level, back-of-the-envelope, quick-turn around LCC estimate that can be used by "top level" decision makers. Since the objective of the "top level" cost estimates takes CAIV into account, this document will be helpful prior to Milestone 0 and Milestone I in the system acquisition life cycle. The examples only go to work breakdown structure level 2. References are given and the coster is shown how to document and report LCC IAW DOD 5000.4M. Also, readers are warned about some common costing traps that can easily occur. An inflation tutorial instructs how to convert the cost of one fiscal year to another. The document has limited potential for a seasoned, well experienced coster.

14. SUBJECT TERMS
Life Cycle Cost;LCC;Cost as an Independent Variable;CAIV;Cost Methodology;Work Breakdown Structure;WBS;Cost Breakdown Structure;CBS;Cost Analysis;RT&E Cost; Production Cost;O&S Cost;Parametrics;Cost Estimating Relationships;CER;Space Systems

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TOP LEVEL SPACE COST METHODOLOGY

(TLSCM)

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I. Introduction

Life cycle cost education, resources, and data have been declining over the past several years. This challenge is the reason the Top Level Space Cost Methodology(TLSCM) document was created. However, this document is not to be considered as a cost model nor a reference source but rather an illustration of cost methodologies to help you accomplish top level life cycle costing.

Life cycle cost(LCC) is the total cost to the government of acquisition and ownership of a system over its entire life. It includes cost of development, acquisition, operation, support and where applicable, disposal costs. This definition of LCC is IAW DoDI 5000.2 which establishes LCC as the official methodology of conducting and reporting cost estimates. This illustrative document will present a space systems example in concurrence with these instructions and with the cost reporting format of DoD 5000.4-M for a "coster" (anyone who estimates cost).

An inexperienced coster needs some place to start. This document may help him or a non-coster obtain some insight or at least get an inkling on how or where to begin.

To illustrate why LCC is so important let us revert back into history a bit for some worth while experience, i.e. General Billy Mitchell. General Billy Mitchell demonstrated that airborne power is the "high ground". Space power today is the same as what airborne power was then. We are always striving for that high ground be it on the battlefield or wherever and with that high ground usually comes a cost. LCC tries to identify that cost of the high ground and we will try to help you identify that cost via examples of some LCC methodologies.

To illustrate these LCC methodologies we could have chosen ground, airborne, or space systems; however, we chose the space arena. This document marries the importance of space with the cost of its "high ground".

To further illustrate the importance of achieving this "high ground" especially with our chosen surveillance DSP space example is a quote from Ronald R. Fogleman, US Air Force Chief of Staff: "A Vision for the 21st Century Air Force", delivered to the Heritage Foundation, Washington, Dec. 13, 1996. Ref.(28:4).

> Another item in the area of space that received a great deal of attention during the Gulf War was the sensor system used to detect missile launches. The Defense Support Program, or DSP, satellites, that gave us warning of the SCUD missile launches during the Gulf War, had always been important from the national missile warning perspective. But Desert Storm showed us how important this kind of system could be for defending against theater ballistic missiles. In DSP, we had a system that was decades old and, despite some technology upgrades, would not precisely identify the location of missile launches. We needed a better system to support U.S. forces operating in a world of theater ballistic missiles, so we made our next priority the Space-Based Infrared System, or SBIRS.

Because space systems are so important we will always need a top level cost estimate for the next generation system/s. This document will help you accomplish that objective by illustrating costing techniques through some simple examples. We picked a third generation surveillance system to illustrate these costing techniques. By following these examples you can complete a LCC estimate of any space system and become a integral part of the top level decision process.

A. Purpose: The purpose of this document is to help the reader calculate Rough-Order-of-Magnitude(ROM) space LCC estimates by showing examples of cost methodologies. This document provides examples in the space mission area of surveillance. These examples are intended to give an inexperienced coster and others a methodology for developing top-level, quick turn-around, rough-order-of-magnitude cost estimates. Our examples contain useful information about methodologies, factors, and cost estimating relationships(CERs) that can be used in a generic sense on other space systems.

B. Scope: This methodology document is intended to be used as a quick and handy resource for costing methodologies, factors and cost estimating relationships and it isn't intended to answer all space cost questions. For more complete space costing information, documents, sources, references, etc., see Attachment 8. References.

II. Life Cycle Cost Methodologies

A. Life Cycle Cost Categories: There are three primary LCC categories; Research, Development, Test, and Evaluation(RDT&E), Investment or Procurement, and Operation and Support(O&S). A fourth category, Disposal, may be included in more advanced LCC estimates.

1. Research, Development, Test, and Evaluation(RDT&E).

This LCC category consists of identifying all the costs associated with those resources required in the research, development, test, and evaluation of a system, subsystem or a major component during acquisition. RDT&E encompasses the concept exploration/definition, demonstration/validation, and engineering and manufacturing development phases.

2. Investment.

This category identifies the total costs of procuring the prime mission equipment and its support; e.g., command and launch equipment, support equipment, training, data, initial spares, war reserve spares, pre-planned product improvement, and military construction. Investment includes the accumulated cost of the production and deployment phase(sometimes called the procurement phase).

3. Operation and Support(O&S).

This category is also known as operation and maintenance(O&M) cost which identifies the costs of those resources required to operate and support a system, subsystem, or a major component during its useful life in the operational inventory. If you can identify manpower and training requirements then you can estimate an annual O&S cost, which makes the costing of this category very simple. Simply multiply the annual O&S cost times the number of years of economic life, i.e. 10 years economic life would be 10 times the annual O&S costs.

4. Disposal.

This category captures all cost to phase out and/or eliminate the system from the inventory. It is sometimes referred to as salvage cost and it includes any realized receipts from the sell of disposed of systems/equipment. It identifies the costs of all activities to dispose of the system, be it clean-up, destroy, put in storage, and/or sell as salvage. However, at pre-milestone 0 it is difficult to estimate disposal costs since you don't know for sure what the system looks like or its composition. Therefore, we are not including disposal costs in any of our examples.

B. Cost/Work Breakdown Structure(CBS/WBS): The Work Breakdown Structure(WBS) is a method of diagramming the work to be accomplished by separating the work content into individual elements. When cost is entered for these individual work elements it is known as a Cost Breakdown Structure(CBS). The space WBS presented below is shown to reflect the third level.

Level 1	Level 2	Level 3
Surveillance Monitoring System(SMS)		
	Surveillance Monitoring Satellite (Spacecraft/ Bus/Payload)	
		Spacecraft
		Payload 1...n
		Reentry Vehicle
		Orbit Injector/Dispenser
		Integration & Assembly

The levels go much deeper but normally for pre-milestone 0, and milestone 0, level 2 WBS is sufficient. Therefore, for documentation ease we will only show cost to level 2 in our examples. Level 3 is more appropriate with Milestone I or II. As suspected the levels and number of line items for a space system may be extensive. Definitions down to level 3 are noted in Mil-Std-881B on pages F-4 to F-9 and in our Attachment 1, Cost Terms and Definitions.

1. Simplified WBS: The following is a simplified level 2 WBS from Mil-Std-881B(2:F1-F3).

Level 2

- Launch Vehicle
- SMS Spacecraft/Bus/Payload
- Ground Command, Control, Communications and Mission Equipment
- Systems Engineering/Program Management
- Systems Test and Evaluation
- Training
- Data
- Peculiar Support Equipment
- Common Support Equipment
- Operational/Site Activation
- Flight Support Operations and Services
- Storage
- Industrial Facilities
- Initial Spares and Repair Parts

2. Launch Segment: Provides the capability to place and replace space assets in orbit. Launch operations or spacelift operations deliver space systems to the required operational orbit or location in space. The launch segment includes preparing the various segments of the space launch vehicle, erecting or stacking the launch vehicle on or near the launch pad, integrating the mission payload(s) with the launch vehicle, conducting a thorough pre-launch checkout of all systems, and conducting the actual operations of countdown, launch, and flight of the space vehicle into orbit. Ref.(23:85)

3. Ground Segment: The ground segment is used for reception and processing of satellite data, and for distribution of this information to the users. The ground segment or C3 operations consists of the following:

Mission Control Station
Mission Control Station Back-up
Relay Ground Station Europe
Relay Ground Station Pacific
Multi-mission Mobil Processor

4. **Space Segment:** The space system element refers to the complex of hardware, data services and facilities required for the placement, operation, and recovery of vehicles in space. It is the comprehensive maintenance of achieving an operational capability in space.

5. **Software:** Software may be considered a level three WBS but we are going to include it as if it were a level two. There are several software models to predict the cost but we will use a simple model developed by TRW which is based on real-time Air Force and space programs. Ref.(25:2-8, 2-9)

6. **ACEIT:** Automated Cost Estimating Integrated Tools(ACEIT), Tecolote Research, Inc. There is a way to use the ACEIT cost program to get a print-out of an expanded WBS. Therefore, find someone that has ACEIT experience and run an expanded WBS list--using the line items that you need.

C. **Ground Rules and Assumptions:** Every LCC estimate has ground rules and assumptions and they must be stated up front. Assumed ground rules have a tremendous affect on the cost and they should be well thought out since they can change the LCC drastically. A generic set of ground rules for any LCC estimate is contained in Attachment 3, Ground Rules and Assumptions. In our SMS example we state some specific ground rules. However, for this document and our examples we have some basic ground rules and assumptions as follows:

* We will assume for our example that the characteristics and concept of operations of a space based surveillance system, i.e. Defense Support Program(DSP) and/or Space Based Infrared System(SBIRS) is equivalent to our Surveillance Monitoring System(SMS) example. Therefore, we will use DSP and SBIRS as analogous systems.

* No disposal costing will be attempted.

* No separate fee or contractor fee is included.

* All final cost figures were inflated to FY 97$ using OSD inflation indices.

* No learning or improvement curve analysis is applied.

* No time spreading of cost by FY.

D. **Typical Life Cycle Cost Distribution:** Life cycle costing for space historically has a different cost distribution than ground or airborne weapon systems. The following charts in Figure 1 depict this difference. Ref.(4:8263-92). Use of this historical chart allows us to use the simple methodologies to estimate top level LCC estimates.

E. **Methodologies:** The potential for developing any ROM cost estimate will be based on what we need to do and the data availability to do it with. To start the process, certain data must be collected allowing the estimator to generate the cost estimates, i.e. the following is necessary:

* Identify the LCC elements to be addressed.
* Develop the data that represents the LCC elements for the system.
* Identify the concept of operation.
* Identify the scenarios that you will utilize.

* Identify the quantities involved.
* Identify the life cycle involved.

When you have quantified the data from the above steps then you can proceed to develop a ROM cost estimate by using one or more of the following methodologies:

* Cost/budget threshold.
* Analogy
* Parametrics
  ** CERs
  ** Prime mission equipment
  ** Factors
* Bottom-up/expert opinion

The cost distributions from Figure 1 below are different for ground/airborne/conventional systems vs. space systems. The original source of this cost distribution data is the AFSC Affordable Acquisition Approach Study and we use this data heavily in our examples and calculations. In our calculations we have used the following Cost Distributions:

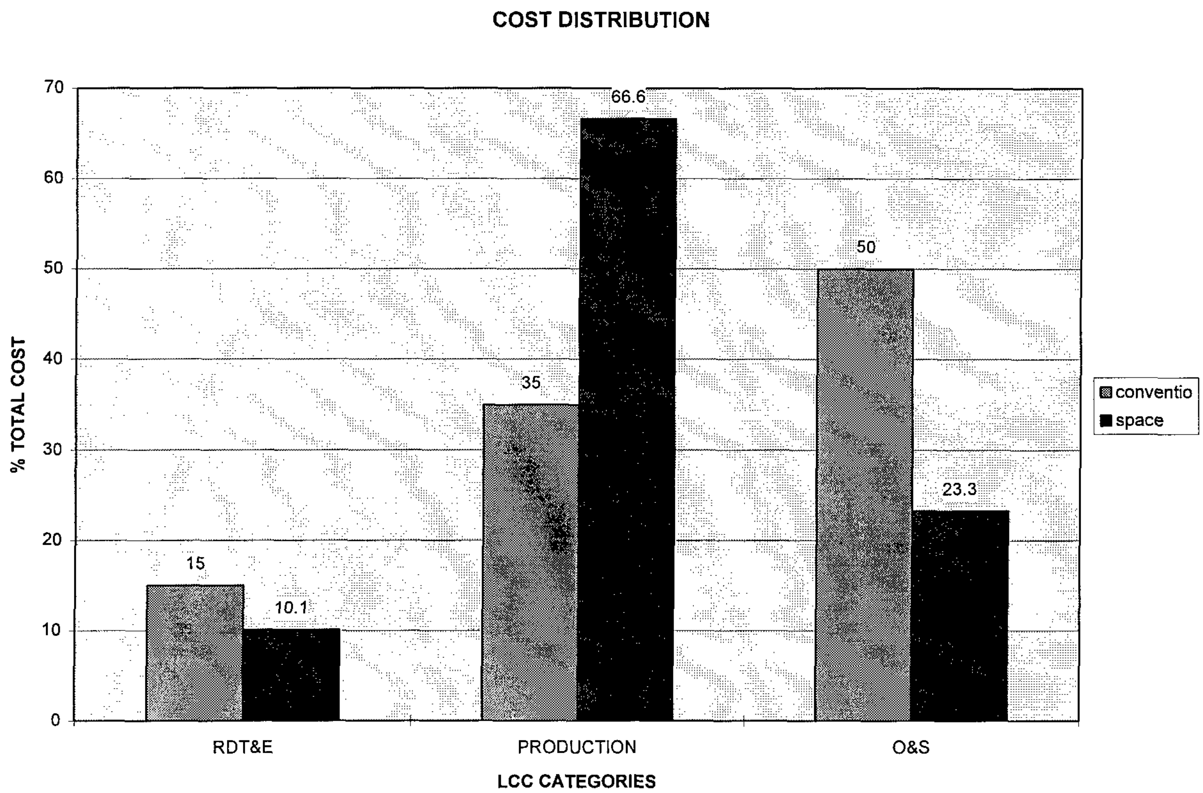
Space

RDT&E = 10.1%
Prod. = 66.6%
O&S = 23.3%

Ground/conventional

RDT&E
  Dem/val. = 3.0%
  FSD = 12.0%
Prod. = 35.0%
O&S = 50.0%

FIGURE 1



Source: AFSC AFFORDABLE ACQUISITION APPROACH STUDY

1. **Cost/budget Threshold Methodology.** Our simplest portrayed methodology, cost/budget threshold, is presented first with the more complex estimating methodologies to follow. We say simplest because this methodology is constrained by specific assumptions--mainly the budget. This methodology is based on a LCC not to exceed a total figure of an established budget threshold. By breaking this cost/budget threshold down into not to exceed percentages of each particular LCC category(See Figure 1 and Table 1), we can state the relative value of each LCC category. This would be what is called a "Back-of-the-envelope" estimate. This first methodology is based upon a cost/budget threshold with a relative value of the LCC categories. This methodology is the simplest form of a LCC estimate--that is if you know the budget/cost ceiling threshold.

This methodology lends itself to the Cost as an Independent Variable(CAIV)or maybe it could be said in this case Budget as an Independent Variable(BAIV).

First, you would develop or use a certain percentage for each LCC category--in this methodology you are given specifics for the space arena. Next, identify the total dollar threshold(cost/budget) associated with this space system or program. Then you would multiply the percentage for each LCC category by the total dollar threshold for the program. Lastly, sum the elements for the total LCC and you have a simple "Back-of-the-Envelope" ROM LCC estimate.

Table 1, which corresponds with Figure 1 is a recommended allocation of the budget/cost threshold.

TABLE 1

LCC Allocation Percentages

LCC Category	% Allocation
RDT&E	10.1 %*
Investment	66.6 %*
O&S	23.3 %*
Total LCC	100.0 %*

Ref. (4:8263-92)
Source: Aerospace Corp.

NOTE*: These percentages are specific values developed by the AFSC Affordable Acquisition Approach Study. They are reliable for quick "back-of-the-envelope" estimates and can be used if you have a cost/budget threshold.

2. **Analogy Methodology.**

Analogy is really a comparative estimating methodology based on actual costs of a similar existing or past programs and adjusting for known or projected complexity, technical, or physical differences to derive the new system estimate. This method requires that we research thoroughly both systems(past & future upgrades) to gain insight into the differences and make adjustments to the LCC either upwards or downwards.

3. **Parametric Methodologies.**

Parametric LCC estimates are derived from statistical correlation of historical system costs with performance and physical attributes of the system. This methodology is another estimating technique which employs one or more cost estimating relationships(CERs). It involves collecting relevant historical data at an aggregated level of detail and relating it to the area to be estimated through the use of mathematical techniques. This methodology uses CERs, build-up of prime mission equipment costs, and/or factors to predict the costs.

a. Cost Estimating Relationships(CERs). A CER is a mathematical expression which describes, for predictive purposes, the cost of an item or activity as a function of one or more independent variables. There are numerous CERs you can use if you research the ACEIT data base plus several other cost models, i.e. Unmanned Space Vehicle Cost Model, 7^{th} Edition. You will need to pick a CER that best fits your described system. Almost all spacecraft CERs are broken down to the sub-system level(level 3 or 4); but, for our purposes here we are only attempting to show level 2.

Most CERs will usually state a specific fiscal year dollar; therefore, to bring the equation to current year dollars you will have to multiply times the proper inflation indices.

b. Prime Mission Equipment(PME). This methodology uses the primary equipment of the mission to derive or base the building blocks of the cost estimate. Estimating the cost of the PME will give you the basis to use many CERs that can give you the different LCC line items of your cost estimate.

c. Factors. This methodology is actually a CER in which the cost is directly proportional to a single independent variable. It is a brief arithmetic expression wherein cost is determined by application of a ratio such as a percent. It is used as a multiplier and which, when combined with, or related to other factors, contributes to produce a cost estimate.

4. Bottom-up/expert Opinion.

This methodology is sometimes referred to as the engineering or "grass roots" approach and refers to getting quotes at the "bottom level" of the contractual work segments. Also know as "expert opinion" it is using the experts in engineering, manufacturing, procurement, testing, etc. to come up with "best estimates". This methodology can produce a more exact cost estimate. An analogous contract is even better to capture the actual cost data. If you have actual contracts that you can quote by all means do so. This methodology also encompasses what is referred to as the Delphi approach, or a consensus of opinion of numerous experts. This bottom-up estimate is very detailed down to the bolts and nuts level which is more detailed than just a quick ROM estimate. Even though, this methodology is the more accurate estimate; it is very time consuming. This document will not try to illustrate this methodology because it is too detailed for what we are illustrating.

III. Examples

We have defined the basic methodologies, and now we will show you examples of each. We could have shown examples along with the methodology definitions; but, we chose to have a separate section on examples. The SMS example involves the combination of methodologies of analogies, parametrics, CERs, and factors to derive the cost of the prime mission equipment. We will use all of the noted methodologies. We will illustrate three separate examples but we will only apply the cost report format to the parametric methodology example.

A. Cost/budget Threshold Example:

1. Assumptions. Our specific assumptions for this example are as follows:

* The cost or budget ceiling is a threshold that is given and isn't to be exceeded.

* The percentages available from historical data bases Ref.(4:8263-92) are similar to the SMS and will be used here for each LCC category.

* Program cost/budget is not to exceed $22.63B FY95. Ref.(14:9)

2. Threshold. The $22.63B FY95 figure comes from the SBIRS approved Single Acquisition and Management Plan(SAMP) 16 Oct. 1995 of the Program Office Estimate(POE). $22.63BFY95/.960 = $23.57BFY97(inflated only because we use this figure later). We will use this figure as an example to illustrate the cost/budget threshold methodology.

3. Process. The process is as follows:

a. Develop relative cost value as a percentage, for each LCC category.

b. Multiply the percentage for the LCC category of the system times the program cost/budget threshold dollars.

c. Summarize the total LCC elements dollar amount for the total LCC.

LCC Category	% Allocation	Threshold	LCC FY 97
		$23.57B	
RDT&E	10.1 %		$ 2.38B
Investment	66.6 %		$15.70B
O&S	23.3 %		$ 5.49B
Total LCC	100 %		$23.57B

Based on the above example, using relative values we are able to develop a cost for each LCC category, while the cost does not exceed the threshold given for the program. This may be applied by the Using Command when the affordability issue is a major consideration. This is also the philosophy of Cost as an Independent Variable(CAIV) where establishment of targets can be established.

B. Analogy Example:

The DSP program was projected at $11.55BFY90 Ref.(10:9) $11.55BFY90/.839 = $13.77BFY97. SBIRS program high concept is estimated to be $22.63B(FY95) Ref.(14:9) $22.63/.960 = $23.57BFY97 or a 71% increase in cost over the first generation space based surveillance system. Let's assume that we can take advantage of learning from the DSP and SBIRS programs and guesstimate that a third generation surveillance program will cost 75% more than the second generation. Under the analogy methodology we are only trying to estimate what the cost will be in relationship to the analogous system--be it more or less. Therefore, our guesstimated cost is that the SMS program will cost no more than $23.57 X 1.75 = $41.25BFY97. Now the LCC breakout is as follows:

LCC Category	% Allocation	Threshold	LCC FY97
		$41.25B	
RDT&E	10.1 %		$ 4.17B
Investment	66.6 %		$27.47B
O&S	23.3 %		$ 9.61B
Total LCC	100 %		$41.25B

Of course you can break the LCC categories down further into CBS/WBS but you'll need a lot more information.

For a better in depth perception to the analogy process we will go further into detail than we did with the cost/budget threshold method. In our SMS example the proposed objective is to estimate the LCC of a follow-on third generation surveillance system to the Defense Support Program(DSP) and Space Based Infrared System(SBIRS). DSP and SBIRS are therefore our analogous systems. If we note the differences of the systems we can increase or decrease the costs of the SMS in relationship to the analogous systems.

We theorize that the SMS will incorporate new technology with improved coverage and sensor sensitivity; more rapid re-targeting and revisit times, for continuous coverage as well as multiple missions; hardware and software technology advancements; on-board processing thereby increasing speed, accuracy, and reliability of gathered data. The SMS is a real time, on-line global Battle Damage Assessment(BDA) surveillance satellite system that has on-board processing and is survivable in nuclear and laser environments. The SMS program will have multiple missions; therefore, it will use GEO as well as elliptical orbits. It will have on-board maintenance capability and can be serviced from the space station. There will be three satellites in GEO. "GEO constellation sizes typically range from three to five satellites. A minimum of three is required for complete equatorial coverage, and five provide some overlap and coverage to all but the Earth's polar regions." Ref.(27:12) These three GEO satellites plus the Draim constellation of four satellites in elliptical orbits totals

seven active satellites in orbit that will provide continuous Earth coverage. One spare inactive satellite will be docked in each separate orbit making a total of nine satellites. One of these satellites will be the prototype that has been built to fly.

The following Table 2 is a simplification of constellation characteristics of the analogous systems compared to our projected SMS example: (Please remember that the SMS constellation characteristics are only theorized, not anything actual nor anything planned.)

TABLE 2

DSP, SBIRS and SMS Constellation Characteristics

CHARACTERISTICS	DSP	SBIRS****	SMS (Projection)
Weight	4663#*	3334#	6000#
Orbit GEO HEO LEO		<4.6 degrees classified TBR	
Power	1265* watts	1835 watts	3000 watts
Altitude GEO HEO LEO	Geostationary	 Geosynchronous HighlyElliptcal 1600 KM	Geostationary Highly Elliptical Driam Constellation
Scan	10 seconds		5 seconds continuous*****
Spinning	yes 3-axis***		yes 3-axis
Refresh Rate			
On Board Processing	No***		Yes
Quantity(on orbit)	3 Active 1 spare**	GEO 4 HEO 2 LEO Classified	GEO 3 Spare 1 HEO 4 Spare 1 7 active***** 2 spares
Quantity(R&D+ total)	22(4-R&D)	11+(5-R&D)	9(1-R&D that flys)
Launcher	Titan IV/Cent. Titan IV/IUS	AtlasIIAS/IPS EELV	Titan IV Cent./IUS
Design Life	2.25 yrs	8 years(est.)	10 years
Hardened	No	No	Nuclear, Radiation, EMP, Lasers, KEW
Manpower Rqtment Plus 14% Overhead	737****| 103est.|Total 840	285****| 40 est.|Total 325	250 | 35 est.|Total 285
Payload	Sensors: IR Telescope Laser Cross Link Mission Data Message***	Sensors: IR Telescope Scanning Sensor Signal Processor GEO payload	Sensors: IR Telescope BDA sensors On Board Processors

NOTES: *Ref. (13:9326-93)
**Ref. (14:7)
***Ref. (18:4-10)
****Ref. (24:1-6, 1-11, 1-23, 1-104, 1-228, 8-1, B-5, D-3)
*****Ref. (1:189)

Due to our requirements of on-board processing equipment and continuous scanning for BDA it is going to require some new design technology, estimated at 50% additional effort. With a 50% new design

effort or 1.5 x prime mission equipment cost will give us an increase in our estimated PME cost. To illustrate, the DSP prime mission equipment satellite average unit cost Ref.(13:4013-92) as $323.60MFY94 X 1.5 = $485.40MFY94/.942 = $515.29MFY97. So by analogy this is how much the PME will cost just because of the added design effort.

Now just for an excursion for our analogy example only, we are going to show you how complexity factors can affect the total cost. They are complex within themselves and they have to be used judicially. To illustrate this we are going to assume that survivability is the utmost requirement and we need completely hardened satellites. Therefore, complexity factors need to be applied and they are as follows:

Hardening:	Nuclear*	0.07 x	prime mission equipment cost
	Radiation**	0.4 x	prime mission equipment cost
	EMP*	2.75 x	prime mission equipment cost
	Lasers*	2.1 x	prime mission equipment cost
	KEW*	3.25 x	prime mission equipment cost
Total Hardening		8.57	Complexity factor

Notes: *Midpoint factors. Ref.(22:5-6)
**Electronics estimated to be ¼ of PME so ¼ of midpoint 1.6 is 0.4.

Complexity Factor X Prime Mission Equipment = New PME cost
8.57 X $515.29MFY97 = $4,416.04M
or $4.42BFY97/ satellite

You can readily see why we haven't hardened our satellites and it emphasizes again that the assumptions and ground rules you establish are critical and they play a big part of cost estimating.

However, let us proceed on with the LCC from this point(using hardened satellites).

RDT&E cost with 1 prototype is as follows:

RDT&E Element	Prime Mission Eqt. Cost	Factor	Total$MFY97
Integration, Assembly, Test	$4,416.04M	12.5%	$ 552.01
System Integration	$4,416.04M	9.0%	$ 397.44
System Engineering	$4,416.04M	7.5%	$ 331.20
Program Management	$4,416.04M	10.0%	$ 441.60
System Test and Evaluation	$4,416.04M	11.5%	$ 507.84
Prototypes(1)	$4,416.04M	1 X	$4,416.04
		Total	$6,646.13

Now that we have the prime mission equipment cost($4,416.04MFY97) and we have approximated the RDT&E cost($6,646.13MFY97) we can guesstimate and back into the total LCC, as we did before, by going back to our first example of LCC projections. Again from TABLE I, the RDT&E represents 10.1% of the total LCC. Therefore, if 10.1% X LCC = $6,646.13M(RDT&E costs), then the total LCC would be $65,803.31MFY97 or $65.80BFY97. Using this LCC total figure we can guesstimate all categories as follows:

RDT&E = 10.1% = $ 6,646.13MFY97
Investment = 66.6% = $43,825.01MFY97
O & S = 23.3% = $15,332.17MFY97
LCC TOTAL = 100.0% = $65,803.31MFY97 or $65.80BFY97

C. Parametric Example:

1. Cost Estimating Relationships(CERs). First, we will utilize the simplest case that we can. Since there have been 17 DSP satellites produced we are going to devise our own CER by taking these 17 data points

and doing a linear regression to devise an equation that we can use for our prime mission equipment. The data is as follows:

DSP Satellite Number	X = (Number of lbs) Dry Weight	Y = Unit Cost($M)
1	1834	135.7
2	1834	135.7
3	1834	135.7
4	1834	135.7
5	2500	216.5
6	2500	216.5
7	2500	216.5
8	2500	216.5
9	2500	216.5
10	2500	216.5
11	2500	216.5
12	3500	234.3
13	3500	234.3
14	4663	323.6
15	4663	323.6
16	4663	323.6
17	4663	323.6

When we take this data and do a linear regression on it, the equation is as follows:

Average Unit Cost Y = 54.55970987 + 0.057809114(X No. of lbs.)

This equation has a correlation R^2 = .9206; therefore, it is highly dependent on the variable of weight. Within the space arena weight is usually a cost driver with a high correlation factor.

We will use this CER later in another example to predict the cost of the prime mission equipment. It should be noted that this equation is presented in FY97 dollars even though we could have normalized the data by inflating the cost of each data point. However, just for simplicity and to just illustrate the example we didn't adjust the cost data points.

There are other CERs that can be used, i.e., another parametric CER taken from Space Mission Analysis and Design Ref.(1:726) shows a CER for spacecraft bus as 16,253 + 110X^1.0KFY92 with X being dry weight in kg.; but, our projected SMS is assumed to weigh 6,000 pounds or 2,700kg(6,000 X .45) or 16,253 + 110(2,700kg) = $313,253KFY92 or $313.25MFY92/.900 = $348.06MFY97. However, the range weight for this CER is only 26 to 897 kg and we are projecting nearly four times over the maximum range. Therefore, we suggest you validate meaning that you confirm or do a reasonable double check on your CERs before using them. In this case we aren't suggesting to use this CER but it is shown to illustrate validation or non-validation and indicating that other CERs might be necessary.

Next, we will show some applicable parametric CERs: Please note that Non-recurring Cost refers to a one time cost and Recurring Cost means that it is a repetitious cost.

RDT&E Category:

Non-recurring(NR) Costs: First, we show some non-recurring cost CERs for the RDT&E category. Ref.(19:5-2 & 5-3)

Spacecraft:

Y = 43.600 X Spacecraft Wt.(lbs.)

Y = Total Spacecraft NR cost, FY92$(K)

Notes: 1. Must inflate to current year dollars.
2. Caution if SC weight is outside data range of 520 to 2543#.

Integration, Assembly, and Test(IA&T):

Y = 956.384 + 0.191(Spacecraft NR cost)

Y = Total IA&T NR cost, FY92$(K)

Notes: 1. Must inflate to current year dollars.
2. Caution if SC NR cost is outside data range of $2,324 to $340,094 FY92$.

Aerospace Ground Equipment(AGE):

Y = 8.304 X (Spacecraft NR cost)^0.638

Y = total AGE NR cost, FY92$(K)

Notes: 1. Must inflate to current year dollars.
2. Caution if SC NR cost is outside data range of $21,036 to $500,118 FY92$.

Investment/Production Category:

Recurring(R) Costs: Next, we show some recurring cost CERs for the Investment/Production category.

Spacecraft:

Y = 19.025 X Spacecraft Weight(lbs.)

Y = First Unit Cost, FY92$(K)

Notes: 1. Must inflate to current year dollars.
2. Must use learning curve theory to calculate cumulative costs.
3. Caution if spacecraft weight is outside data range of 340# to 3,063#.

Integration Assembly and Test(IA&T):

Y = 4.833 X Spacecraft Weight(lbs.)

Y = First Unit Cost, FY92$(K)

Notes: 1. Must inflate to current year dollars.
2. Must use learning curve theory to calculate cumulative costs.
3. Caution if spacecraft weight is outside data range of 340# to 3,063#.

Launch Operations and Orbital Support(LOOS):

Y = 11.111 X (Spacecraft weight in lbs.)^0.647

Y = First Unit Cost, FY92$(K)

Notes:
1. Must inflate to current year dollars.
2. Must use learning curve theory to calculate cumulative costs.
3. Caution if spacecraft weight is outside data range of 462# to 5,687#.

Operation and Support(O&S)/Maintenance Category:

Recurring(R) costs: Now, we show some recurring cost CERs for the Operation and Support or Maintenance Category.

Next, we show some applicable CERs that can be split between the LCC categories.

We can show data and training Ref.(26:III-96,III-98) in all three LCC categories because you have these costs in all three categories. Once you calculate the total data and training cost then you can break it into the historical percentage of 10.1% for RDT&E, 66.6% for Investment, 23.3% for O&S. This is a simple method that is consistent with our methodology and has some justification.

Data:

Y = 0.0122(SUMTOT)

Where: Y = Lot total cost of government required data, both recurring and non-recurring, FY 85$(K)

SUMTOT = Lot total cost of all other activities both recurring and non-recurring, FY 85$(K).

Notes:
1. Must inflate to current year dollars.
2. Caution if R and NR cost is outside data range of $55,909 to $738,099 FY85$.

Training:

Y = 0.00123(SUMTOT)

Y = Lot total cost of training, both recurring and non-recurring, FY85$(K).

SUMTOT = Lot total cost of all other activities, both recurring and non-recurring, FY85$(K).

Notes:
1. Must inflate to current year dollars.
2. Caution if R and NR cost is outside data range of $56,646 to $739,059 FY85$.

Systems/Program Management can be split between RDT&E and Investment categories. AFSC Cost Estimating Handbook Series, Vol. VI, Space Handbook, Dec. '89 Ref. 20, p. 150 reflects a Systems/Program Management combined factor for the RDT&E and Investment phases of 37%. Therefore if you have a factor or can calculate a factor for either the RDT&E category or Investment category and subtracting this factor from the 37% you will have the remaining category factor. You could have higher or lower than 37% because reference 20, p. 150 reflects a range of 11 to 86%.

On Site Activation can be also be split between RDT&E and Investment category. Use the same procedure as systems/program management with a combined factor of 13% Ref. (20:150) for the RDT&E and Investment categories. Again you could have higher or lower than the 13% because reference 20, p. 150 reflects a range of 0.20 to 35.40%.

2. **Prime Mission Equipment(PME).** PME simply is the equipment that is primarily being costed or it is the primary item of the system, i.e. in our SMS example the PME is the SMS satellite. If you can construct an estimate for the PME you have the basis of constructing a LCC estimate.

Using our derived CER equation(para II.C.1. Cost Estimating Relationships) and applying our SMS estimated weight parameter of 6,000 pounds as noted in para. II.B.2. Analogy, we can calculate the average unit cost of our prime mission equipment. The estimate is as follows:

Average Unit PME Cost Y = 54.55970987 + 0.057809114(X no. of lbs.)

Average Unit PME Cost Y = 54.55970987 + 0.057809114(6000#)

or

PME = $401.41MFY97

The next generation of precision guided weapons(PGW) will heavily use space assets for guidance; therefore, protection of these space assets is imperative and hardening will be a necessary reality. Our requirement for hardening requires that our satellites be more complex than the previous DSP and SBIRS satellites and we will thus need to apply hardening complexity factors. Most of the complexity comes from making the satellite more survivable by hardening all components to all threats. We will say that the complexity factor is 8.57 noted in para. III.B. Analogy Example and explained further in para. III.C.3. Factors.

Y = PME cost X Complexity Factor
Y = $401.41M X 8.57
Y = $3,440.08MFY97 or $3.44BFY97

Where: Y = Average unit cost of our prime mission equipment.

Ref.(1:734) indicates that RDT&E Cost equals 2.5 X unit costs. This unit cost we are assuming to be equivalent to PME cost and we aren't equating it to total unit production cost. Therefore use 2.5 times in accordance with this statement. "A rule of thumb for satellite development costs is that RDT&E(non-recurring) costs are 2 to 3 times the unit costs". Ref.(1:734) Again, this statement needs to be scrutinized especially with the ground-rules chosen, i.e. where is the unit cost(prototype) placed-- RDT&E or Investment category. The caution here is where do you put the unit costs, is it first unit cost, average unit cost, etc. This is why it is critical to scrutinize your methodology. Then if we used this rule of thumb methodology then 2.5 X $3,440.12MFY97 = $8,600.30M or $8.60BFY97 for the RDT&E category.

Now that we have calculated the RDT&E cost($8,600.30MFY97) we can now guesstimate the LCC another way as we did before, by going back to our first example of LCC phase projections. Again from TABLE I, the RDT&E phase represents 10.1% of the total LCC. Therefore, if 10.1% X LCC = $8,600.30MFY97(RDT&E costs), then the total LCC would be $85,151.49MFY97 or $85.15BFY97. Using this LCC total figure we can guesstimate all the LCC categories as follows:

RDT&E	=	10.1%	=	$ 8,600.30MFY97
Investment	=	66.6%	=	$56,710.89MFY97
O & S	=	23.3%	=	$19,840.30MFY97
LCC TOTAL	=	100.0%	=	$85,151.49MFY97 or $85.15BFY97

3. **Factors.** A cost factor is a brief arithmetic expression wherein cost is determined by the application of a factor as a proportion. We have already shown examples of factors through the hardening complexity factors in the analogy paragraphs.

Here are some RDT&E multiplicative factors that you might want to consider in your estimates:

RDT&E Multiplicative Factors

New design with advanced development	>1.1
Nominal new design	1.0
Major modification to existing design	0.7-0.9
Moderate modifications	0.4-0.6
Basically existing design	0.1-0.3

Reference(1:728)

Complexity factors can adjust the final parametric estimate. Below are some documented complexity factor guidelines to follow for adjustments.

Program Management(PM) Complexity Factors:

(1). Under Program Management cost there is a complexity factor due to increased weight. Increasing the weight has been known for a long time to increase the cost. In the case of Program Management of the total LCC cost, increasing the dry weight of the spacecraft by one percent will increase the overall program management cost by 0.59%. Ref.(7:IV-7) The data base from which this factor came from had a weight range of 1,178 to 34,437 pounds.

(2). Under Program Management cost there is a complexity factor due to building a prototype. Since a prototype approach requires an additional spacecraft, non-recurring program management cost would logically increase. Building a prototype spacecraft will increase the total LCC Program Management cost by a factor of 2.86. Ref.(7:IV-7)

Systems Engineering(SE) Complexity Factors:

(1). Under SE cost there is also a complexity factor due to increased weight. Increasing the weight has many separate effects. In the case of SE of the total LCC cost, increasing the dry weight of the spacecraft by one percent will increase the overall total non-recurring SE cost by 0.44%. Ref.(7:IV-10)

(2). If the spacecraft being estimated is operational, the total non-recurring SE LCC increases by a factor of 3.65. However, if the modification SE is modification to an existing design or follow-on, the total SE decreases by a factor of 0.42. Ref.(7:IV-10)

System Test and Evaluation(ST&E)Complexity Factors:

(1). There is a complexity factor to ST&E; for each 1% increase in production quantity there is an increase of total non-recurring system test of 0.38%. Ref.(7:IV-13)

(2). Another complexity factor for ST&E is for every 1% increase of beginning-of-life power the total non-recurring ST&E increases by 0.75%. Ref.(7:IV-13)

(3). There is others factors for ST&E. If the system is operational, the cost increases by a factor of 4.11; if it is a

modification to an existing design, it decreases by a factor of 0.17. Ref.(7:IV-13)

If we have an estimate of the prime mission equipment we can estimate the cost of the RDT&E category via the cost breakdown structure and using the programmatic cost factors as a percent of prime mission equipment. The following table documents factors of ranges that you might use:

TABLE 3

COST FACTORS AS A PERCENTAGE OF PRIME MISSION EQUIPMENT COST

Element	Factor(%)	Source of Recommendation
RDT&E Category		
Integration, Assembly, Test	5-20	DCA Cost Manual
System Integration	8-10	DCA Cost Manual & NASA CDOS
System Engineering	5-10	DCA Cost Manual & SCC Handbook
Program Management	10	DCA Cost Manual
System Test and Evaluation	5-18	DCA Cost Manual & ESD Study
Other Elements		
Training	2-4	DCA Cost Manual & SCC Handbook
Data	6-14	DCA Cost Manual & SCC Handbook
Support Equipment	4-18	SCC Handbook & Aerospace LV Cost Model
Operational/Site Activation	7-18	DCA Cost Manual & ESD Study
Initial Spares/Repair Parts	8-23	SCF Cost Manual & ESD Study

Notes:

DCA Cost Manual	-Defense Communication Agency Cost & Planning Factors Manual, March 1983
NASA CDOS	-NASA CDOS Cost Analysis: Mitre Report, MTR-089Q0001, Circa 1989
ESD Study	-ESD Cost Factor Study, March 1978
SCC Handbook	-SDI Command Center Cost Handbook, Circa 1990
SCF Manual	-Satellite Control Facility Cost Manual, Oct. 1981

Of course use of these factors(low, mid, or high range) will depend upon your particular system. But for our example to find the RDT&E category cost we will again use a simple approach by taking the midpoint of the above ranges and applying them to our cost breakdown structure.

RDT&E cost example with 1 prototype

RDT&E Category Element	Prime Mission Eqt. Cost	Factor	Total$MFY97
Integration, Assembly, Test	$3,440.08M	12.5%	$ 430.01
System Integration	$3,440.08M	9.0%	$ 309.61
System Engineering	$3,440.08M	7.5%	$ 258.01
Program Management	$3,440.08M	10.0%	$ 344.01
System Test and Evaluation	$3,440.08M	11.5%	$ 395.61
Prototypes(1)	$3,440.08M	1 X	$3,440.12
		Total	$5,177.37

Costs from "Other Elements"(mid-point) from the above factors list are utilized below; however, they can be distributed across all LCC categories. They are shown here to continue the example of the factors methodology.

Other Elements	Prime Mission Eqt. Cost	Factor	Total$MFY97
Data	$3,440.08M	10.0%	$ 344.01
Support Equipment	$3,440.08M	11.0%	$ 378.41
Operational/Site Activation	$3,440.08M	12.5%	$ 430.01
Initial Spares/Repair Parts	$3,440.08M	15.5%*	$ 533.21

Note: * A planning factor used by some elements of the Air Force is 20% of the hardware costs. Ref.(22:8-6) We used 15.5% here but the 20% is within the 8-23% as noted above.

Now that we have the prime mission equipment cost($3,440.08M) and we have calculated the RDT&E cost, we can guesstimate and back into the total LCC by going back to our first example of LCC category projections. If you will recall from TABLE I the RDT&E category represents 10.1% of the total LCC. Therefore, if 10.1% X LCC = $5,177.37M(RDT&E costs), then the total LCC would be $51,261.09M or $51.2B. Using this LCC total figure we can guesstimate all the LCC categories as follows:

RDT&E	=	10.1%	=	$ 5,177.37MFY97	
Investment	=	66.6%	=	$34,139.89MFY97	
O & S	=	23.3%	=	$11,943.83MFY97	
LCC TOTAL	=	100.0%	=	$51,261.09MFY97	or $51.26BFY97

As shown earlier hardening of the satellites may or may not be under consideration. If the spacecraft requires hardening against nuclear radiation, ionizing radiation, electromagnetic pulses(EMP), lasers, and kinetic energy weapon(KEW) shock then the following factors can be utilized:

Nuclear: 7%(Spacecraft cost-both NR & R)
Ref.(20:67)
Source: Aerospace Study (around 1979)

Radiation: 1.2-2.0(cost of unhardened electronic system)
Ref.(22:5-5)

EMP: 1.5-3.0(cost of unhardened system)
Ref.(22:5-5)

Lasers: 1.2-3.0(cost of unhardened system)
Ref.(22:5-6)

KEW: 1.5-5.0(cost of unhardened system)
Ref.(22:5-6)

Most software cost is dependent upon number of lines of code written or developed. The parametric model shown here is similar to lines of code written since it is based on size or number of machine-level instructions(MLI). It takes the form of:

$$\text{man-months(MM)} = A(I)^B.$$

Where: A = is a coefficient = 0.0384
I = number of MLI or the size of the program
B = an exponent = 0.9708

Please note that this equation will give you the software level of effort if you can estimate the total number of MLI. Then you would have to multiple by the cost per man-month(present day, FY97, salary thought to be $6,250 to $8,333 per month). Also, please note that this software model is not very accurate but it does give a ROM estimate.

D. Surveillance Monitoring System(SMS) Example

This example will encompass all of the methodologies and we will put the cost figures into the cost format as shown in Attachment 4. There are two caveats for this section: First, it is more important to see the procedures of how to capture a LCC estimate than what equations were actually used. So please don't get hung up on numbers per se because this

section shows the procedures involved to illustrate the example only! It is not to be copied in any fashion for any future LCC! Second, to report the O&S cost we have adjusted the LCC reporting format(DoD 5000.4M) somewhat to make it match our space operations. The space operations(O&S) format was adapted from the USAF CBS to SDI, 1986. Ref.(21:24) You may have to do something similar with your ROM LCC estimate; however, to lessen the confusion stay closely aligned with the DoD 5000.4M cost format.

The rational and source referencing is very important; therefore, we have tried to document and reference each step. The purpose of this example is to show you the steps you go through to document and reference your data and how you might arrived at a your ROM LCC.

For this all encompassing example we will change some of the previous ground rules and assumptions slightly but they will dramatically alter the LCC totals that we have calculated thus far. These new ground rules and assumptions are as follows:

* Considering Cost as an Independent Variable(CAIV), hardening of satellites is too expensive for the budget; therefore, this requirement has been deleted. Please note that this would be a typical example of applying Cost as an Independent Variable(CAIV)--where it is too expensive for the budget.

* Satellite life expectancy of an SMS is 10 years.

* Quantity of SMS satellites is nine with one as a prototype. Seven on active orbit with two spares in orbit. Constellation will consist of three satellites in GEO Ref.(27:12) and four satellites in the Draim constellation orbit. Ref.(1:189) One spare will be for the GEO orbit and the other spare will be for the Draim constellation orbit.

* All satellites will be equal in cost.

* One prototype satellite will fly later as one of the four primary on-orbit satellites.

* Data and Training cost apply to all LCC categories and we will allocate the costs of RDT&E as 10.1%, Investment 66.6%, and O&S 23.3%. See TABLE 1.

* Spare parts will be purchased in both the RDT&E and Investment categories even though the two spare satellites are costed in the Investment category.

* Software is considered a level 2 WBS.

* Software with the on-board processing is assumed to be 10 million machine-level instructions(MLI) for all LCC phases. The total cost of man-months will be allocated RDT&E as 10.1%, Investment 66.6% and O&S 23.3%. See TABLE I. We assume the software salary of one man-month as $8,333.33/mo. Or $100K/yr FY97.

* Personnel cost for O&S manning(Mil. or Civ.) is $75K/yr FY97.

* Direct support manning for SMS for military, civilian, and contractor support is 285 authorized slots with 14% overhead Ref.(24:5-11) or an additional 40 slots making a total of 325 slots allocated directly to SMS.

* Operation and Support is 10 years making this a 10 year LCC regardless of the life of the system.

* System and Application Software is not costed as integral part of the Prime Mission Equipment but as a separate line item. However, this line item is still included in the Flyaway cost.

* To estimate payload cost we will use an analogy of SBIRS payload working weight(769.2#) to satellite dry on-orbit weight(3,204.7#) Ref. (24:B-5) a ratio of 24%. This ratio will be used to calculate the payload cost portion of the prime mission equipment.

* By analogy for the O&S Space Segment Operations we will assume a like operations cost which was considered under DSP. Ref. (18:4-50) "The orbital support provided by the spacecraft contractor...Current program office estimates to support satellites 14-21 are $7.6M per year." This is in FY 84$ for 8 satellites and we have 9; therefore, X = 9($7.6M)/8 equals $8.55MFY84/.689 = $12.41MFY97 per year for space operations.

* Military construction is assumed to be similar to the projected costs of the Follow-on Early Warning System(FEWS) estimate of $39MFY91. Ref. (29:c-1-1). $39MFY91/.875 = $44.57MFY97.

* Manning is estimated to be 325 slots with 1/3 (108 slots)being military.

* RDT&E lasts 5 years with IOC at the end of the 5 years.

* Government Fee is not included

Using these ground rules and assumptions as well as our CERs and factors we will now create and display our SMS LCC estimate IAW DoD 5000.4M.

SMS 10 Year Life Cycle Cost Example

(All dollars in millions FY97 unless otherwise noted)

RESEARCH AND DEVELOPMENT

Cost FY97M

CONCEPT EXPLORATION/DEFINITION PHASE
DEMONSTRATION/VALIDATION PHASE
ENGINEERING AND MANUFACTURING DEVELOPMENT PHASE

Prime Mission Equipment $ 684.66

Structure, Integration, Assembly, Test and Checkout

Structure(spacecraft wt.) Ref.(19:5-2&5-3)

```
$43.60KFY92  X SC wt.   =
$43.60KFY92  X 6,000#   =
$261.60MFY92/.900       =          $290.67
```

Complexity Factor: design complex. fac. X Structure

```
     .5 X $290.67     =            $145.33
  Spacecraft Non-recurring Cost    $436.00
```

Integration, Assembly, Test and checkout
Ref.(19:5-2&5-3)

```
$956.384KFY92   + 0.191(SC NR cost)=
$956.384KFY92   + 0.191($436.00)   =
$956.384KFY92/.900 +0.191($436.00)=
$1,062.65KFY97 + 0.191($436.00)   =
$1.06MFY97      + 0.191($436.00)   =  $ 84.34
                 Avg. Satellite Cost  $520.34
```

Propulsion(Note: integral part of spacecraft)

Installed Equipment(Payload)
Payload to satellite weight ratio = 24% Ref.(24:B-5)
(100% - 24%) X (RDT&E PME Cost) = $520.34
76% X (RDT&E PME Cost) = $520.34
RDT&E PME Cost = $684.66
24% X ($684.66) = $164.32

System and Application Software Ref.(25:2-8&2-9) 201.86
Cost of Man Months for RDT&E Phase =
.0384(# MLI)^.9708 X cost/MM X 10.1% =
.0384(10,000,000)^.9708 X $8,333.33 X 10.1% =

System Test and Evaluation 78.74
RDT&E PME Cost X 11.5% =
$684,660KFY97 X 11.5% =

System Engineering/Program Management 119.82
System Engineering
RDT&E PME Cost X 7.5% =
$684,660KFY97 X 7.5% = $ 51.35

Program Management
RDT&E PME Cost X 10.0% =
$684,660KFY97 X 10.0% = $ 68.47

Flyaway Cost Non-add $1,085.08
This is a non-add item to the total LCC but it does reflect the above items that are added to derive the Flyaway cost. It is shown here just to illustrate what the Flyaway Cost encompasses.

Support Equipment(Air, Ground Equipment--Peculiar and Common) 36.56
Ref.(19:5-2&5-3)
$8.304KFY92 X (SC NR cost)^0.638 =
$8.304KFY92 X ($436,000KFY97)^0.638 =
$8.304KFY92/.900 X $3,962.71KFY97=
$9.227KFY97 X $3,962.71KFY97=

Training Ref.(26:III-96&III-98) 2.33
0.00123(SUMTOT R & NR)MFY85$ X RDT&E percentage =
0.00123SUMTOT((RDT&E R & NR) + (Investment R & NR)) X RDT&E%=
0.00123(($684.66M + $201.86M + $78.74M + $119.82M + $36.56M + $106.12M + $85.58M) + ($6,749.73M + $1,331.09M + $1,316.19M + $3.43M + $33.74M + $742.47M + $1,046.20 + $843.71M) X 10.1% =
0.00123(($1,313.34M) + ($12,066.56M))MFY85 X 10.1% =
0.00123($13,379.90)MFY85 X 10.1% =
$1.66MFY85/.712 =

Data Ref.(26:III-96&III-98) 23.16
0.0122(SUMTOT R & NR)MFY85$ X RDT&E percentage =
0.0122SUMTOT((RDT&E R & NR) + (Investment R & NR)) X RDT&E%=
0.0122(($684.66M + $201.86M + $78.74M + $119.82M + $36.56M + $106.12M + $85.58M) + ($6,749.73M + $1,331.09M + $1,316.19M + $3.43M + $33.74M + $742.47M + $1,046.20 + $843.71M) X 10.1% =
0.0122(($1,313.34M) + ($12,066.56M))MFY85 X 10.1% =
0.0122($13,379.90)MFY85 X 10.1% =
$16.49MFY85/.712 =

Initial Spares and Repair Parts		106.12
RDT&E PME Cost X 15.5% =		
$616,190KFY92 X 15.5% =		
$95.51MFY92/.900 =		
Operational/Site Activation		85.58
RDT&E PME Cost X 12.5% =		
$616,190KFY92 X 12.5% =		
$77.02MFY92/.900 =		
Industrial Facilities		
In-house(Specify)		
Contingency/Risk Factor		
Other		
TOTAL RESEARCH, DEVELOPMENT, TEST, AND EVALUATION		$1,338.83
MILITARY CONSTRUCTION		44.57
$39.00MFY91/.875 =		
MILITARY PERSONNEL		40.62
325Total Auth. Slots X 1/3(mil) X $75,000/yr X 5years =		
TOTAL RESEARCH AND DEVELOPMENT	7.95%	$ 1,424.02
NUMBER OF UNITS:		1

INVESTMENT

PRODUCTION AND DEPLOYMENT PHASE

Prime Mission Equipment:		$6,749.73
Avg. Satellite unit cost x no. units		
$520.34MFY97 x 8 =	$4,162.72	
Structure, Integration, Assembly, Test and Checkout		
Structure(spacecraft) Ref.(19:5-2&5-3)		
$19.025KFY92 X SC wt.		
$19.025KFY92 X 6,000# X 8 =		
$913.20MFY92/.900 =	$1,014.67	
Integration, Assembly, Test and checkout		
$4.833KFY92 X SC wt. Ref.(19:5-2&5-3)=		
$4.833KFY92 X 6,000# X 8 =		
$231.98MFY92/.900 =	$ 257.76	
Propulsion(Note: integral part of spacecraft)		
Installed Equipment(payload) Ref.(24:/B-5)		
24%(PME Cost) = Payload Cost		
24%($616.19MFY92) = $147.89MFY92		
$147.89MFY92 X 8 =		
$1,183.12MFY92/.900 =	$1,314.58	
System and Application Software		1,331.09
Cost of Man Months for Investment Phase =		
.0384(# MLI)^.9708 X cost/MM X 66.6% =		
.0384(10,000,000)^.9708 X $8,333.33 X 66.6% =		
System Engineering/Program Management Ref.(20:150)		1,316.19

Investment PME Cost X Investment Cost factor =
$6,074.70MFY92 X (Combined factor - RDT&E factor) =
$6,074.70MFY92 X (37% - 17.5%) =
$6,074.70MFY92 X 19.5% =
$1,184.57MFY92/.900 =

Command and Launch Equipment(Launch Ops & Orbital Support-LOOS) 3.43
$11.111KFY92 X (SC wt.)^0.647 Ref.(19:5-2&5-3) =
$11.111KFY92 X (6,000#)^0.647 =
$3.09MFY92/.900 =

Platform Modification(Operational/Site Activation) 33.74
Investment PME Cost X Investment Cost factor Ref.(20:150) =
$6,074.70MFY92 X (Combined factor - RDT&E factor) =
$6,074.70MFY92 X (13% - 12.5%) =
$6,074.70MFY92 X 0.5% =
$30.37MFY92/.900 =

Support Equipment(Air, Ground Equipment--Peculiar and Common) 742.47
Investment PME X Factor =
$6,074.70MFY92 X 11% =
$668.22MFY92/.900 =

Training 15.39
0.00123(SUMTOT R & NR)MFY85$ X RDT&E percentage =
0.00123SUMTOT((RDT&E R & NR) + (Investment R & NR)) X Investment % =
0.00123(($684.66M + $201.86M + $78.74M + $119.82M + $36.56M +
$106.12M + $85.58M) + ($6,749.73M + $1,331.09M +
$1,316.19M + $3.43M + $33.74M + $742.47M + $1,046.20
+ $843.71M) X 66.6% =
0.00123(($1,313.34M) + ($12,066.56M))MFY85 X 66.6% =
0.00123($13,379.90M)MFY85 X 66.6% =
$10.96MFY85/.712 =

Data 152.69
0.0122(SUMTOT R & NR)MFY85$ X RDT&E percentage =
0.0122SUMTOT((RDT&E R & NR) + (Investment R & NR)) X RDT&E%=
0.0122(($684.66M + $201.86M + $78.74M + $119.82M + $36.56M +
$106.12M + $85.58M) + ($6,749.73M + $1,331.09M +
$1,316.19M + $3.43M + $33.74M + $742.47M + $1,046.20
+ $843.71M) X 66.6% =
0.0122(($1,313.34M) + ($12,066.56M))MFY85 X 66.6% =
0.0122($13,379.90)MFY85 X 66.6% =
$108.71MFY85/.712 =

Initial Spares and Repair Parts 1,046.20
Investment PME X Factor =
$6,074,700KFY92 X 15.5% =
$941.58MFY92/.900 =

Operational/Site Activation 843.71
Investment PME X Factor =
$6,074,700KFY92 X 12.5% =
$759.34MFY92/.900 =

Industrial Facilities(Included under Mil. Con.—RDT&E) NA
Other procurement

TOTAL PROCUREMENT $12,234.64
MILITARY CONSTRUCTION(Costed in RDT&E Category) NA
OPERATION AND MAINTENANCE(Costed in O&S Category) NA
MILITARY PERSONNEL(Costed in the total under O&S Category) NA

325 personnel X 1/3 = 108 military

TOTAL INVESTMENT	68.29%	$12,234.64
NUMBER OF UNITS:		8

OPERATING AND SUPPORT*

OPERATIONS PHASE

Operations 3,354.92

Launch

9 launches(4 to GEO & 5 to HEO)Ref.(1:731)
via TitanIV/Centaur G @ $286MFY92
9 X $286.00MFY92 =
$2,574.00MFY92/.900 = $2,860.00

Space Ref. (18:4-50)
$8.55MFY84/yr X 10yrs=
$85.50MFY84/.689 = $ 124.09

Ground
Mobil Ground System Ref.(13:9325-93)
$35.60MFY95/yr X 10yrs =
$356.00MFY95/.960 = $ 370.83

MAINTENANCE PHASE

Space Maintenance] 243.75
Ground Maintenance]
Space & Ground O&S = 325persons X $75,000/yr X 10yrs

Software Maintenance 465.70
Cost of Man Months for O&S =
.0384(# MLI)^.9708 X cost/MM X 23.3% =
.0384(10,000,000)^.9708 X $8,333.33 X 23.3% =

SUPPORT PHASE

Mission Training 5.39
0.00123(SUMTOT R & NR)MFY85$ X RDT&E percentage =
0.00123SUMTOT((RDT&E R & NR) + (Investment R & NR)) X RDT&E%=
0.00123(($684.66M + $201.86M + $78.74M + $119.82M + $36.56M +
$106.12M + $85.58M) + ($6,749.73M + $1,331.09M +
$1,316.19M + $3.43M + $33.74M + $742.47M + $1,046.20
+ $843.71M) X 23.3% =
0.00123(($1,313.34M) + ($12,066.56M))MFY85 X 23.3% =
0.00123($13,379.90)MFY85 X 23.3% =
$3.83MFY85/.712 =

Support Facilities and Services
Personnel Acquisition and Training

OTHER 188.40

Data
0.0122(SUMTOT R & NR)MFY85$ X RDT&E percentage =
0.0122SUMTOT((RDT&E R & NR) + (Investment R & NR)) X RDT&E%=
0.0122(($684.66M + $201.86M + $78.74M + $119.82M + $36.56M +
$106.12M + $85.58M) + ($6,749.73M + $1,331.09M +
$1,316.19M + $3.43M + $33.74M + $742.47M + $1,046.20
+ $843.71M) X 23.3% =
0.0122(($1,313.34M) + ($12,066.56M))MFY85 X 23.3% =

0.0122($13,379.90)MFY85 X 23.3% =
$38.03MFY85/.712 = $53.42

Travel/Miscellaneous Support Ref.(18:13-30)
$1.60MFY84/yr X 10 years =
$16.00MFY84/.689 = $23.22

Production/Launch Support Ref.(18:13-30)
$3.40MFY84/yr X 10 years =
$34.00MFY84/.689 = $49.35

Computer Lease/Maintenance Ref.(18:13-30)
$4.30MFY84/yr X 10 years =
$43.00MFY84/.689 = $62.41

TOTAL OPERATING AND SUPPORT	23.77%	$ 4,258.16

Ref.(21:24)
Source: USAF CBS Format Mapping to SDI, 1986

GRAND TOTAL LIFE CYCLE COST	100.0%	$17,916.82

It is interesting to note that RDT&E percentage is 7.95% as compared to Figure 1 and Table 1 of 10.1%; Investment/production is 68.29% as compared to 66.6%; and O&S is 23.77% as compared to 23.3%.

V. Cost Analysis

Doing a quick look at our documented simple examples we have shown methodologies of a third generation space surveillance system(with different ground rules and assumptions) costing from a low range of $17.92B to a high range of $85.15B in current fiscal year 97 dollars. The range without hardening is $17.92B to $41.25B and with hardening is $51.26B to $85.15B

Cost/Budget Threshold Methodology:	
Cost/Budget threshold(SBIRS Program)	$23.57
Analogy Methodology:	
Analogy via cost/budget	$41.25
Analogy via PME build-up (with hardening)	$65.80
Parametric Methodology:	
Parametric via PME build-up (with hardening)	$85.15
Parametric via Factor build-up(with hardening)	$51.26
Surveillance Monitoring System Example:	
SMS via CER, PME, and Factor build-up	$17.92

It is interesting to note that the low range of $17.92 is where we spent more time and effort in calculating our ROM LCC estimates. Our LCC calculations are what we consider "most likely" figures but at this stage(Pre-milestone 0) they can only be stated with slight confidence by reflecting a range of the ROM cost. The following is suggested:

Methodology Example Ranges
(All figures in FY 97 Billion Dollars)

METHODOLOGY	MOST LIKELY	-/+ 15 PERCENT	-/+ 50 PERCENT*
Cost/Budget threshold	$23.57	20.03 to 27.11	11.79 to 35.36
Analogy of C/B threshold	$41.25	35.06 to 47.44	20.62 to 61.87
Analogy via PME Build-up	$65.80**	55.93 to 75.67	32.90 to 98.70
Parametric via PME	$85.15**	72.38 to 97.92	42.58 to 127.73
Parametric via Factor	$51.26**	43.57 to 58.95	25.63 to 76.89
SMS Example	$17.92	15.23 to 20.61	8.96 to 26.88

Note: * Ref. (12)
** Hardened Satellites

By noting a range you can be more confident about your ROM LCC estimate. As the program/system progresses to higher milestone phases more and better cost figures will become more definite and the coster as well as the budgeter can focus in on a point estimate versus a range of cost figures.

Please remember that a range is sufficient for pre-milestone 0; but it isn't good enough to establish a budget. It does however give the decision makers a "feel" for the budget, its ramifications and a chance to consider CAIV. This is where CAIV can play a very important role up front in the decision process, i.e. making the decision not to harden the satellites.

In our examples we would have a hard time making comparisons strictly on cost because the alternatives have different requirements, i.e. hardening. Therefore, we will not make any cost analysis comparisons; we are only illustrating the various methodologies and techniques of costing.

Validity of the LCC estimate will depends on what information you have or can guesstimate. Accuracy will also depend upon how much time and effort you can devote to capturing the cost data. Our objective is for a quick turn around, top level, back of the envelop ROM LCC estimate. Therefore, please remember parametrics, definitely has more detail; analogy, if the system configuration is very closely similar to another system may be more accurate; and budget threshold, which we showed as the simplest, isn't usually a reality because rarely do you have a "should cost".

Normally you don't have a budget until you have an approved program. Hopefully, this document has given you some insight of estimating the ROM LCC for the decision makers so they can make some up front decisions to develop a budget.

To help you with your cost analysis there are many cost analysis computer models around and discussion of them is beyond the scope of this document. However, for your convenience a partial listing is noted in Attachment 6.

The economic life or life cycle is a major decision that must be answered up front for the cost analyst. Just what is the life expectancy and how will it be costed? The answer will impact the LCC tremendously, i.e. if you are costing a 10 year life cycle but the satellite has only a life expectancy of 7 years this means that a 2nd satellite will have to be launched within the 10 years to accomplish the mission. The number of launches normally is a cost driver that can have a big impact on the final cost figures.

Sensitivity analysis is an important part of the process of a LCC estimate. It is the repetition of an analysis with different quantitative values for selected parameters or assumptions for the purpose of comparison with the results of the basic analysis. If a small change in the value of

the variable results in a large change in the LCC, then the costs are sensitive to that parameter or assumption. If a variable or parameter is shown to be sensitive to changes then it is considered to be a "cost driver". There is no predetermined percentage of change in the LCC estimate that identifies a "cost driver", but only if it makes a significant change in the bottom line figures. By doing this you can identify the cost drivers. Interestingly, a primary cost driver in the space area is not a cost item at all--it is weight. Weight is always a cost driver with space operations.

To obtain a more qualified LCC estimate there are more advanced costing techniques that may be necessary that are outside the scope of this document. We will give you a short synopsis of these techniques.

A. Advanced Cost Techniques: Due to the limited scope of this document, some of the more advanced cost estimating techniques have not been discussed, i. e. net present value/discounting, risk analysis, cost improvement(learning) curves, etc. All of these techniques are necessary in the more refined and detailed estimates supporting the later milestone decisions. However, remember that the purpose of this document is to help you develop a top-level, back of the envelope, ROM LCC estimate for pre-milestone 0 or milestone 0. Therefore, these advanced cost techniques will only be mentioned here without showing examples(with one exception) of how to accomplish them. That one exception concerns inflation which we showed in the SMS example and this technique is explained fully in Attachment 8. There are several excellent cost documents that can show you how to use these techniques, i.e. AFSC Cost Estimating Handbook(AFMC change pending).

1. **Net present value/discounting.** A technique for converting forecasted amounts to economically comparable amounts at a common point in time, considering the time value of money. The time value of money is considered by computing present value costs. Present value cost are computed by applying a discount rate to each year's cost in a cost stream. Discount rates are usually developed to closely approximate the current cost of money in the financial marketplace. The purpose of discounting is to determine if the time value of money is sufficiently great to change the ranking of alternatives--a ranking that has been established on the basis of all other considerations. It also must be said that discounting is highly controversial in the costing community as well as what discount rate to use. One basic reason for the controversy even though the procedure is simple you are really doing a sensitivity analysis on "the cost of money" not a sensitivity analysis on the alternatives per se--and who knows what the cost of money will be in the future.

2. **Risk Analysis.** A situation in which the outcome is subject to an uncontrollable random event stemming from a known probability distribution. There is cost risk, as well as technical, production, and schedule risk. There are several risk analysis programs that help analyze cost.

3. **Cost Improvement/Learning Curves.** A theory that states that as the quantity of items produced increases, costs decrease at a predictable rate. "Unit" cost improvement curve theory describes the relationship between the cost of individual units. "Cumulative average" theory describes the relationship between the average cost of different quantities of units. The equation is as follows. It must be mentioned that learning curves is a very integral part of aircraft production(where it got its start) and for ground based systems because they are relative large production lots. However, in the space craft production it is usually not a factor due to the few number of items produced; many times only one of a kind.

Typically for space systems theoretically a 95%(SMC/FMC policy--Ref.(12)) cost improvement curve can be used. If the unit production

schedule is less than 10(frequent in the space area) there is some problems with using the cost improvement curve theory equation.

4. **Inflation.** A rise in the general level of prices. Pure inflation is defined as a rise in the general level of prices unaccompanied by a rise in output(productivity). We inflate cost figures via the OSD Inflation Indices that is put out each year. Since we are DoD, we should use the OSD indices and not some other set, i.e. NASA nor a set derived by yourself. If you are using the ACEIT program it can automatically update the figures in accordance with the OSD indices. Our SMS example shows inflation conversions in several areas--please see Attachment 8 for a tutorial on inflation.

5. **Confidence Level.** The degree of probability that actual cost will fall within an expressed interval, e.g., + or - 50% of the Most Likely cost figure. In the past the norm used to be 15% of the estimated cost, but today a higher percentage of 50% is chosen. Ref.(12) The cost model CRYSTAL BALL can be used in this procedure.

6. **Then year dollars.** Budget dollars which reflect purchasing power at the time expenditures are actually made. Sometimes referred to as escalated or inflated costs. Prior costs expressed in then year dollars are the actual amounts paid out in these years. Future costs stated in then year dollars are projected actual amounts to be paid. Normally, in pre-milestone 0 and in milestone 0 the delivery schedules are not known; therefore, then year dollars can not be calculated nor shown. The budget and POM are different because they have to show then year dollars for project funding. LCC is always reflected in base year dollars but not always done in then year dollars. Therefore, it should be recognized that there is a big difference between base year constant dollars and then year dollars. Base year dollars is appropriate for comparing alternatives; whereas, a budget emphasis requires then year dollars.

7. **Uncertainty and uncertainty analysis.** A situation in which the outcome is subject to an uncontrollable random event stemming from an unknown probability distribution. It is a systematic analysis of the range of probable costs about a point estimate based on considerations of requirements, cost estimating, and technical uncertainty.

B. Cautions/traps: We do need to mention some common cost "traps" that you need to be aware of and be cautious about while you are devising your ROM LCC estimate.

1. **Base Line Case.** When costing alternatives always identity a base line case. Sometimes this may be a challenge and when the present system(usually the one being replaced) is the base line case it will usually have the best cost advantage due to sunk costs. The base line case and the analogy methodology are usually complimentary since actual cost can be captured and projected with complexity factors to derive the LCC estimate for another alternative. If you will relative rank these alternatives against the base line case you have become a success in the cost arena.

2. **Cost vs. Price.** Cost is the amount paid or payable for the acquisition of materials, property, or services. In contracts and proposals, "cost" denotes dollar amounts exclusive of fee or profit, i.e. "cost" does not include profit or fee. Whereas "price" includes profit or fee and is the dollar value a vendor will sell its product for or commit to a contract. Price includes a profit or fee(usually not-to-exceed 15%) that is added to the cost. So in most LCC estimates we must state whether fee is included or not.

3. **Amortized cost.** This term must be mentioned--Caution is due here, because this is not a LCC term! Amortized cost is a private

business/accounting term and it does not figure into LCC methodology! However, the term may be used in an economic analysis or a break-even point analysis. Again, please remember that DoDI 5000.2 recognizes LCC methodology as the only mode of presentation to the DAB and other decision authorities, and "amortized cost" is a term not to be used in LCC.

4. **Sunk cost.** The total of all past expenditures or irrevocably committed funds related to a program/project. Sunk costs are generally not relevant to decision making as they reflect previous choices rather than current choices. It is sometimes referred to as prior year costs. Sunk costs are normally shown in current year dollars as a total expenditure of that years actual costs. When prior costs are stated in current dollars, the figures given are the actual amounts paid out. However, the decision makers might like to know what the prior sunk cost were. Therefore, you should always try to capture any data on funds already allocated and identify them separately from the LCC estimate. Sunk costs are not added into the LCC estimate figures, but they can describe a new starting place.

5. **Inflation of Sunk Cost:** Sunk costs are "sunk" and supposedly are not relevant to decision making; however, to position a system in relative ranking order you might be requested to inflate that figure. This would be done to normalize the data base you are using. Normally, you don't inflate sunk cost but it can give you an indication what that system would cost in current or today's dollars. Therefore, you are highly cautioned about inflating any sunk costs.

6. **Constant dollars.** Computed values which remove the effect of price changes over time. An estimate is said to be in constant dollars if costs for all work are adjusted so that they reflect the level of prices of a base year. A common trap to fall into is to take cost estimates and figures from different references and do extrapolation calculations without converting to a single base year(constant) dollar. Inflate to constant year dollars unless the dollars are already considered "sunk".

7. **Cost Range.** Ranges of costs can be confusing. Estimating the cost of an item is usually considered the "most likely(ML)" cost but what is a good range above and below this most likely figure. Should there be a plus or minus of this figure. To show a range is being cautious. What is used to obtain the high range and what is used to obtain the low range is questionable. The classical methodology was to use a +/- 15%, now SMC is recommending +/- 50%, and some cost estimates are now showing 70% and even 90%. The more advanced cost techniques may show a skewed relationship to the "most likely" figure. However, to put some standardization to this challenge we recommend using SMC's position of a +/- 50%.

8. **Cost Driver.** The characteristics of a system or end item that have a large or major effect on the systems cost. It isn't necessarily the most expensive components but it is the item that when the cost is varied it causes a large or major effect on the total LCC estimate. As discussed before in the space arena a predominate cost driver is weight and number of launches--both being a non-cost element.

VI. Cost Report Format

The cost format as noted in Attachment 4 is the proper procedure for reporting LCC estimates IAW DoD 5000.4-M, Table 2-2, page 2-12. This table represents a valid WBS/CBS for the RDT&E and Investment/Production categories; however, the entries for the O&S category does not lend itself to space systems so we will give you another breakout that will be helpful. LCC estimates in this format will satisfy all levels of cost reporting up to and including the Defense and Acquisition Board. This document has led you down the path of how to estimate the LCC categories so now all you have to

do is pick your methodology and plug in your estimates for RDT&E, Investment/Production, and O&S.

You will still have to make some judgment calls about specific cost breakouts between the different LCC categories, i.e. how much are training and data costs distributed between the RDT&E and Production/Investment categories; how do you distribute the costs of Launch, Space, and Ground segments; where do you note the costs of prototype satellites—RDT&E vs. Production/Investment; where and how do you allocate the software costs. These are decisions you need to ponder before categorizing your cost estimates. As stated early on in this document, the ground rules and assumption decisions that you make will have great impacts upon the total LCC figures.

You may even have some vacant holes especially in the O&S area since maintenance for space is completely different from ground or airborne systems. Also software cost, which can be significant, may be hard to capture or identify for this report format. However, we provided a simple software cost model in para. III.C. Factors. to help you identify the costs. COCOMO and Price S cost models can help identify software costs if you need more detail. Using these models will definitely require you to go to level 3 WBS/CBS. However, if you stick with level 2 of the cost breakdown structure and our report format you will have a top level ROM LCC estimate recognized throughout the cost community.

ATTACHMENT 1

COST TERMS AND DEFINITIONS

Space System. The space system element refers to the complex of equipment(hardware/software), data, services, and facilities required to attain and/or maintain an operational capability in space. To achieve an operational capability in space, it is necessary to have the ability to develop, deliver, and maintain mission payloads in specific orbits. This requires the ability to develop and produce a capability for the placement, operation, and recovery of both manned and unmanned space systems. Space systems include launch vehicles, orbital transfer vehicles, shrouds, space vehicles, communications, command and control facilities and equipment, and any mission equipment or other items necessary to provide an operational capability in space.

Launch Vehicle. The launch vehicle element refers to the primary means for providing initial thrust to place a space vehicle into its operational environment. The launch vehicle is the prime propulsion portion of the complete flyaway (not to include the orbital transfer vehicle and space vehicle). The launch vehicle may be of a single-stage or multiple-stage configuration. This element includes, for example, the structure, propulsion, guidance and control, and all other installed equipment integral to the launch vehicle as an entity within itself. It also includes the design, development, and production of complete units (i.e., the prototype or operationally configured units which satisfy the requirements of their applicable specification(s), regardless of end use).

Space Vehicle/satellite. The space vehicle element that refers to a complete vehicle(satellite), or group of vehicles placed into space (operational orbit environment). This element includes spacecraft/bus, payload, reentry vehicle and orbit injection/dispenser and integration, assembly, test and checkout. It also includes the design, development, and production of complete units (i.e., the prototype or operationally configured units which satisfy the requirements of their applicable specification(s) regardless of end use). The following comprises the space vehicle/satellite:

Spacecraft/bus. The spacecraft element that refers to the principal operating space vehicle(sometimes called a bus) which serves as a housing or platform for carrying a payload and other mission-oriented equipment in space. This element includes, for example, structure, power, attitude determination and control, and other equipment characteristic of spacecraft. It also includes all design, development, production, and assembly efforts to provide the spacecraft as an entity. All effort directly associated with the remaining level 3 WBS elements and the integration, assembly, test and checkout of these elements into the space vehicle is excluded.

Payload. The payload element refers to that equipment provided for special purposes in addition to the normal equipment integral to the spacecraft or reentry vehicle. It includes, for example, experimental equipment placed on board the vehicle, flight crew equipment (space suits, life support, and safety equipment), communication, displays and instrumentation, telemetry equipment and other equipment that are specifically mission-oriented to collect data for future planning and projection purposes. All effort directly associated with the remaining level 3 WBS elements and the integration, assembly, test and checkout of these elements into the space vehicle is excluded.

Ground C3 and Mission Equipment. The ground command, control, communications, and mission equipment element refers to the ground hardware/software equipment used for: communicating between control and

tracking facilities, monitoring the health and status of space vehicles, commanding the space vehicle's hardware, adjusting the space vehicle's orbit as required for space vehicle health or mission purpose. It includes the design, development , and production of complete units(i.e., the prototype or operationally configured units which satisfy the requirements of their applicable specification(s), regardless of end use). Examples of two configurations for the ground command, control, communications and mission equipment are: the parabolic dish-based antenna system and the phased array-based antenna system. If a ground site has multiple antenna configurations, each will have its own separate command and control equipment, communications equipment, data processing equipment and test equipment.

Systems Engineering/Program Management. This element is defined as the systems engineering and technical control as well as the business management of particular systems and programs. This element encompasses the overall planning, directing, and controlling of the definition, development, and production of a system or program, including functions of logistics engineering and integrated logistics support(ILS) management, e.g., maintenance support, facilities, personnel, training, testing, and activation of a system. Systems engineering/program management effort that can be associated specifically with the equipment(hardware/software) element is excluded. Systems engineering/program management elements to be reported and their levels will be specified by the requiring activity.

Systems Engineering. This element is defined as the technical and management efforts of directing and controlling a totally integrated engineering effort of a system or program . It encompasses the engineering effort to define the system and integrated planning and control of the technical program efforts of design engineering, specialty engineering, production engineering, and integrated test planning.

Program Management. This element is defined as the business and administrative planning, organizing, directing, coordinating, controlling, and approval actions designated to accomplish overall program objectives which are not associated with specific hardware elements and are not included in systems engineering. Today the program management conops requires streamlining and the acquisition office is much smaller than in the past.

Systems Test and Evaluation. This element refers to the use of prototype, production, or specifically fabricated hardware/software to obtain or validate engineering data on the performance of the system during the development phase(normally funded from RDT&E) of the program. It includes the detailed planning, conduct, support, data reduction and reports from such testing, and all hardware/software items which are consumed or planned to be consumed in the conduct of such testing. It also includes all effort associated with the design and production of models, specimens fixtures, and instrumentation in support of the system level test program. Excluded is all formal and informal testing up through the subsystem level which can be associated with the hardware/software element as well as acceptance testing. These excluded efforts are to be included with the appropriate hardware or software elements.

Training. This element is defined as the deliverable training services, devices, accessories, aids, equipment, and parts used to facilitate instruction through which personnel will acquire sufficient concepts, skills, and aptitudes to operate and maintain the system with maximum efficiency. This element includes all effort associated with the design, development, and production of deliverable training equipment as well as the execution of training services.

Data. This element refers to all deliverable data required to be listed on a contract.

Peculiar Support Equipment. This element is defined to include the design, development, and production of those deliverable items and associated software required to support and maintain the system or portions of the system while not directly engaged in the performance of its mission, and which have application peculiar to a given defense materiel item.

Common Support Equipment. This element refers to those items required to support and maintain the system or portions of the system while not directly engaged in the performance of its mission, and which are presently in the DoD inventory for support of other systems. It also includes all efforts required to assure the availability of this equipment for support of the particular defense materiel item. Included also is the acquisition of additional quantities of this equipment if caused by the introduction of the defense materiel item into operational service.

Operational/Site Activation. This element refers to the real estate, construction, conversion, utilities, and equipment to provide all facilities required to house, service, and launch prime mission equipment at the organizational and intermediate level. It includes conversion of site, system assembly, checkout, and installation(of mission and support equipment) into site facility to achieve operational status. It also includes contractor support in relation to operational/site activation.

Flight Support Operations and Services. This element refers to the mate/checkout/launch; mission control; tracking and command, control and communications(C3); recovery operations and services; and launch site maintenance/refurbishment. This element supports the launch vehicle, orbital transfer vehicle, and/or space vehicle during an operational mission.

Storage. This element refers to those costs of holding portions of the space system while awaiting use of the system. These periods of holding are those resulting from schedule changes and/or technological problems exogenous to the portion of the space system being stored, prepared for storage, or recovered from storage.

Industrial Facilities. This element refers to the construction, conversion, or expansion of industrial facilities for production, inventory, and contractor depot maintenance required when that service is for the specific system. It also includes industrial facilities for hazardous waste management to satisfy environmental standards.

Initial Spares and Repair Parts. This element is defined as the deliverable spare components, assemblies and subassemblies used for initial replacement purposes in the materiel system equipment end item. It includes the repairable spares and repair parts required as initial stockage to support and maintain newly fielded systems or subsystems during the initial phase of service, including pipeline and war reserve quantities, at all levels of maintenance and support. This element excludes development test spares and spares provided specifically for use during installation, assembly and checkout on site.

Recurring Cost. Costs associated with program(contract) activities which are repetitive or are related to more than one unit of a production run. Repetitive costs incurred for each item(i.e. prime mission equipment) or each time period of production or test or use. Usually expressed a cost per item or a cost per month and usually occurs during the production or investment LCC categories.

Non-recurring Cost. Fixed costs or one time costs, such as tooling, test equipment, research, and planning, which are generally independent of the

quantity to be produced or tested. Usually occurs during RDT&E LCC category.

Rough Order of Magnitude. A budgetary and planning figure that is usually a rough preliminary figure. This figure is usually contained within groups of tens, i.e. 10, 100, 1000, millions and in our examples a magnitude of billions.

Unit Flyaway Costs. The average flyaway costs(i.e. prime mission equipment) includes the cost of the basic unit fabricated recurring and non-recurring that represents all production costs(contractor and government furnished equipment) that are incurred in the manufacture of a usable end-item.

Base Year Cost/Dollars(BY$). The dollar values expressed as though all funds expended in that year. Dollars which are expressed in economic condition of a specific year and do not include escalation or inflation for future years. A base year dollar reflects the "purchasing power" of the dollar for the specified base year.

Constant Dollars. The dollars expressed at their value in any specified year (rather than a Program's Base Year). A statistical series is said to be expressed in "constant dollars" when the effect of changes in the purchasing power of the dollar has been removed.

Then Year Dollars(TY$). The dollar values expressed in the amounts required to pay costs at time costs are incurred.

Current Dollars. No standard definition; usually synonymous with TY$. Dollars which reflect purchasing power current to the year the work is performed. Sometimes referred to as actual dollars, then year dollars, inflated, or escalated dollars.

Raw Inflation Index. An index that represents the annual compounded inflation rates from a Base Year.

Total Obligation Authority. Total amount of funds available for programming in a given year.

Outlay Profile. The rate at which dollars are expected to be expended.

Weighted Inflation Index. Combines raw inflation indices with an Outlay Profile. An index that represents a combination of raw indices and outlay rates that indicates the amount of inflation occurring over the entire period of time required to expend the total obligation authority.

ATTACHMENT 2

ACRONYMS

$	Dollar
ACEIT	Automated Cost Estimating Integrated Tools
AGE	Aerospace Ground Equipment
B	Billion
BAIV	Budget as an Independent Variable
BDA	Battle Damage Assessment
BY$	Base Year Dollar
C/WBS	Cost/Work breakdown Structure
CARD	Cost Analysis Requirements Document
CAIV	Cost as an Independent Variable
CBS	Cost Breakdown Structure
CBS/WBS	Cost Breakdown Structure/Work Breakdown Structure
CEIT	Cost Engineering Integrated Tool
CER	Cost Estimating Relationship
CY$	Constant Year Dollar
DCA	Defense Communication Agency
DoD	Department of Defense
DoDI	Department of Defense Instruction
DSDPM	Digital Signal Data Processing Model
DSP	Defense Support Program
ELV	Expendable Launch Vehicle
ESD	Electronic System Division
FATES	Fixed and Transportable Earth Stations
FEWS	Follow-on Early Warning System
FY	Fiscal Year
GCN	Ground Control Network
GEO	Geosynchronous Earth Orbit
GTO	Geosynchronous Transfer Orbit
HEO	High Earth Orbit
IA&T	Integration, Assembly, and Test
IAW	In Accordance With
IOC	Initial Operating Capability
IUS	Interim Upper Stage
K	Thousand
Kg	Kilograms
lbs	Pounds
LCC	Life Cycle Cost
LEO	Low Earth Orbit
LOOS	Launch Operations and Orbital Support
LPS	Large Processing Station
LSC	Logistic Support Cost
M	Million
MGS	Mobil Ground System
ML	Most Likely
MLI	Machine-level instruction
MM	Man month
NA	Not Applicable
NASA	National Aeronautical and Space Administration
NR	Non-recurring
O&S	Operation and Support
OPR	Office of Primary Responsibility
OSD	Office of Secretary of Defense
PE	Program Element
PL	Program Level
PM	Program Management
PME	Prime Mission Equipment
R	Recurring

RDT&E	Research, Development, Test, & Evaluation
Ref.	Reference
RLV	Reusable Launch Vehicle
ROM	Rough Order of Magnitude
SBIRS	Space Based Infrared System
SCC	SDI Command Center
SCF	Satellite Control Facility
SDI	Space Defense Initiative
SE	Systems Engineering
SMC/FMC	Space System and Missile Center/Financial Management, Cost
SMS	Surveillance Monitoring Satellite
SMS	Surveillance Monitoring System
SORD	System Operational Requirements Document
SPS	Logistic Support Cost
SSCAG	Space Systems Cost Analysis Group
ST&E	Systems Test and Evaluation
SUMTOT	Sum Total
TLSCM	Top Level Space Cost Methodology
TW/AA	Tactical Warning/Attach Assessment
TY$	Then Year Dollar
USAF	United States Air Force
USCM	Unmanned Spacecraft Cost Model
WBS	Work Breakdown Structure

ATTACHMENT 3

Generic Ground Rules and Assumptions

1. Life cycle costing will be the method of analyzing cost. If LCC methodology is not utilized, a full justification will be necessary. Economic analysis and trade-off studies can be done in addition to the LCC. However, LCC is the foremost and primary means to show cost data and relative ranking of alternatives by equal benefits or equal cost. In many cases only Rough Order of Magnitude(ROM) costing is possible.

2. A baseline case will be identified; if not identified then you will need to establish one.

3. A baseline cost year will be established. The study team usually establishes the year, but if no guidance exists use the fiscal year of when the study will be presented.

4. Do all costing in constant year dollars of the decided upon base year. Costing for budgeting purposes is usually stated in thousands or K dollars but the magnitude of the estimate will determine what dollars to use. Therefore it is best to round-off all calculations to at least 3 decimal places.

5. Use only OSD inflation indices--even working with space items, do not use NASA indices--use OSD indices. We work for DoD not NASA.

6. Unless specifically requested, do not calculate then year dollars. Only if a production schedule is assumed can you calculate then year dollars. In Pre-milestone 0, milestone I and possibly milestone II production schedules may not have been formulated and then you wouldn't know what years to properly portray the monies.

7. Cost all items as if a peacetime production schedule existed.

8. Assume launch on schedule not launch on demand.

9. Cost to the economic life year as directed. However, without guidance cost a 10 year operating life from IOC date. Many satellites are now projecting a 10 year life; however, the constellation system's economic life may be much longer.

10. Start up and phase down cost may be estimated if so directed.

11. Do not attempt to do discounting/net present value unless specifically directed. Discounting is very controversial since it really is a sensitivity analysis on the cost of money and not on the alternatives themselves. Also, the discount rates to be used are extremely controversial and random.

12. Identify all sunk cost items. Do not include sunk costs in LCC figures but identify, document, and show them separately.

13. All military construction costs will be identified. Military construction is part of the total LCC and they should be included in the total life cycle cost figures. Therefore, show all military construction as a separate line item.

14. To do a LCC, the concepts of operation, scenarios, and quantities must be identified. Calculate the constellation size. If no guidance exists then the problem should be bounded with an upper and lower range of quantities.

15. Always identify the most likely(ML) cost figure; then if time permits, do a sensitivity analysis with +/- 50% giving you the low and high range.

16. Cost figures will reflect government cost excluding fee(profit). Do not include vendor fees unless directed and if directed use only a maximum of 15% and show it as a separate line item.

17. All cost figures will be documented and identified by a referenced source. If there is no referenced source then fully document the rationale as to how the cost figures were derived so someone else can replicate and come up with the same results.

18. All methodology will be shown and documented so that it can be replicated by others who follow the rationale, methodology, and referenced sources.

19. A sufficiency review should be done by an individual or an activity other than the one creating the cost estimate.

20. Unit number 1 is assumed to be the first flight article and excludes the qualification model even if the protoflight concept is followed.

21. Amortized Cost is not a DoD recognized LCC cost community term; therefore, it will not be used, period!

22. State whether a fee is included or not.

ATTACHMENT 4

Life Cycle Cost Format

RESEARCH AND DEVELOPMENT

CONCEPT EXPLORATION/DEFINITION PHASE
DEMONSTRATION/VALIDATION PHASE
ENGINEERING AND MANUFACTURING DEVELOPMENT PHASE
- Prime Mission Equipment
  - Structure, Integration, Assembly, Test and Checkout
  - Propulsion
  - Installed Equipment(hardware/software)(Specify)
  - System and Application Software(where applicable)
- System Test and Evaluation
- System Engineering/Program Management
  - Flyaway Cost
- Support Equipment(Air, Ground Equipment(AGE)--Peculiar and Common)
- Training
- Data
- Initial Spares and Repair Parts
- Operational/Site Activation
- Industrial Facilities
- In-house(Specify)
- Contingency/Risk Factor
- Other

TOTAL RESEARCH, DEVELOPMENT, TEST, AND EVALUATION
- MILITARY CONSTRUCTION
- MILITARY PERSONNEL

TOTAL RESEARCH AND DEVELOPMENT
NUMBER OF UNITS:

INVESTMENT

PRODUCTION AND DEPLOYMENT PHASE

- Prime Mission Equipment
  - Structure, Integration, Assembly, Test and Checkout
  - Propulsion
  - Installed Equipment(hardware/software)(Specify)
  - System and Application Software(where applicable)
- System Engineering/Program Management
- Command and Launch Equipment(Specify)
- Platform Modification(Specify)
- Support Equipment(Air, Ground Equipment(AGE)--Peculiar and Common)
- Training
- Data
- Initial Spares and Repair Parts
- Operational/Site Activation
- Industrial Facilities
- Other procurement

TOTAL PROCUREMENT
- MILITARY CONSTRUCTION
- OPERATION AND MAINTENANCE
- MILITARY PERSONNEL

TOTAL INVESTMENT

OPERATING AND SUPPORT*

OPERATIONS PHASE
  Operations
    Launch
    Space
    Ground
MAINTENANCE PHASE
  Space Maintenance
  Ground Maintenance
  Software Maintenance
SUPPORT PHASE
  Mission Training
  Support Facilities and Services
  Personnel Acquisition and Training
OTHER
TOTAL OPERATING AND SUPPORT

Ref.(21:24)
Source: USAF CBS Format Mapping to SDI, 1986

Notes: *Derived from Air Force CBS format to SDI in 1986 for CBS Mapping

ATTACHMENT 5

Launch Cost Factors

"For decades, the US cost to reach space, in constant '93 dollars, has hovered around $8,000 to $12,000 per pound to orbit, both in low earth orbit(LEO) and geosynchronous earth orbit(GEO)." Ref.(17:1)

Expendable Launch Vehicle(ELV)

Launch Vehicle	(kg) Payload-to-Orbit	$M Unit	(FY) Cost	$K/kg Cost per kg
Titan	17,900(LEO)	103.5	(91)	8.9
		160.0	(92)	
Saturn V(SIC +SII)	127,000(LEO)	650.0	(92)	5.1
Ariane 4	17,800(LEO)	120.0	(92)	7.0
Medium Launch Veh	6,600(LEO)	60.0	(92)	9.1
Atlas G/Centaur	5,700(LEO)	78.0	(92)	13.7
Delta/PAM D	3,909(LEO)	60.0	(92)	15.3
Pegasus	455(LEO)	12.0	(92)	26.4
Delta/PAM D	1,420(GTO)	60.0	(92)	42.3
Atlas G/Centaur	2,364(GTO)	78.0	(92)	33.0
Titan IV/Centaur G	12,000(GTO)	286.0	(92)	23.8
Atlas G/Centaur	1,330(GEO)	78.0	(92)	58.6
Titan IV/Centaur G	4,600(GEO)	286.0	(92)	62.2

Note: LEO = Low Earth Orbit
GTO = Geosynchronous Transfer Orbit
GEO = Geostationary Orbit

Ref. Athena Educational Group (1:731)

The Aerospace Corp. has done some WBS level 3 unit percentage cost distribution of ELVs. Below is breakout that could be used in allocating cost.

SRM	32%
Tanks and Structure	22%
Engines	19%
Launch & Flight Ops	12%
Guidance	6%
Fairing	6%
Other	3%

Ref.(9:87-3811)
Source: Aerospace Corp.

Reusable Launch Vehicle(RLV)

Launch Vehicle	(kg) Payload-to-Orbit	$M (FY) Unit Cost	$K/kg Cost per kg
Shuttle	23,090(LEO)	210.0	9.1
Shuttle/IUS	2,270(GEO)	292.0(92)	128.6

Ref.(1:731)

Notes: Shuttle Pricing Algorithm--use larger of: Ref.(1:731)

$$\text{Cost by weight: } \$210M \times \frac{\text{Space System Weight}}{0.75 \times \text{Shuttle capability}}$$

Cost by length: $\$210M \times \frac{\text{Space System Length}}{0.75 \times \text{Shuttle bay length}}$

If [ ] >1, then set equal to 1

ATTACHMENT 6

Cost Models

A. Hardware Models

ACEIT
PRICE
SEER
CEIT

B. Ground Models

Fixed and Transportable Earth Stations Model(FATES)
Ground Station Cost Model
Cost Engineering Integrated Tool(CEIT)

C. Launch Models

Aerospace Launch Cost Model
Launch Vehicle Cost Model
Cost Engineering Integrated Tool(CEIT)

D. Space Models

Aerospace Satellite Cost Model
Aerospace Space Power Cost Model
Digital Signal Data Processor Model(DSDPM)
OSD Spacecraft Cost Model
Small Satellite Cost Model
Unmanned Spacecraft Cost Model(USCM7)
Cost Engineering Integrated Tool(CEIT)

E. Specialized Models

Focal Plane Array Model
OSD Radar Cost Model
Passive Sensor Cost Model
Security System Engineering Cost Model
SHF/EHF Communications Cost Model
System Integration Cost Analysis Model
Focal Plane Manufacturing Process Model
Laser Ranger Finder Cost Model

F. Software Models

COCOMO
PRICE
REVIC
SEER Software Estimating Model
SEER Software Sizing Model
Software Sizing Database Calibration Report
SMC Software Database
Cost Engineering Integrated Tool(CEIT)

G. Operations & Support/O&M Models

Logistic Support Cost(LSC) Model
SEER Hardware Life Cycle Estimating Model
PRICE Hardware Life Cycle Estimating Model
Space Operations and Support Cost Model
SMC Operations and Support Cost Model

SMC operations and Support Database

H. Risk Models

AF Risk Model (RISK)
AFSC Risk Model
@Risk
C Risk Model
FRISK
Plan Risk
Improving Cost-Risk Input Parameters
CRYSTAL BALL

ATTACHMENT 7

Defense Support Program(DSP) CASE STUDY

DSP Program Element (PE 12431F)
FEWS Program Element (PE 63425F)

DSP--Approved Appropriations:

RDT&E	3600	10.1%
Investment	3020	72.2%
O & S	3400	8.3%
Other	3080	9.4%
	Total	100.0%

Ref.(13:8250-92)

Note: This breakout is somewhat different than Figure 1. since it includes a further cost category for "other". However, for RDT&E it is the same and only 5.6% different in Investment allocations.

DSP--Historical Data FY$94

RDT&E $644.2M Sunk Costs

Satellites	Dry Weight(lb)	Unit Costs $M	$K/lb.
1-4	1834	$135.70M	73.9
5-11	2500	216.50	86.6
12-13	3500	234.30	66.9
14-17	4663	323.60	69.5
18-22(est.)	4663	262.90	56.4

Ref.(13:9326-93)

Learning Curve 92% Ref.(13:48)

The following DSP cost is noted in fiscal year by (FY):

		Unit Cost		
Program	Mil Const.	Avg. Cost	Procurement Cost	Program Cost
$11.55B(90)	$27.50M(90)		$382.02M(90)	$444.23M(90)Ref.(10:9)
		$270.00M(90)Ref.(1:735)		
		$323.60M(94)Ref.(13:4013-92)		
		$354.20M(95)Ref.(3:7-1)		

DSP spacecraft/bus/payload unit cost break-out is as follows:

Payload	67.3%
Communications	6.0%
Attitude Control System	11.1%
Structure	4.3%
Electrical Power Subsystem	11.3%

Ref. (9:87-3757)

SPACE SEGMENT:
On Orbit--3 Active 1 spare

Ref.(15:3-1)

LAUNCH SEGMENT:

1. Launch Vehicle Cost.
a. Shuttle: Shuttle recurring cost as a per cent per flight is as follows:

Hardware	55%
Operations	45%
Launch operations	16%
Flight operations	17%
R & PM	10%
HQS/OTDA	2%

Ref.(8:13)

Source: NASA

b. Titan IV: Estimated launch prices—No Upper Stage
$154M FY 90. Ref.(16:47)
Source Isakowitz(1991)

Estimated Cost per flight is as follows:

Hardware	64%
Launch Support	16%
Govn't Support	20%

Ref.(8:13)
Source: Aerospace Corp.

c. TitanIV/Centaur: Estimated launch price-with upper stage
$227 FY 90. Ref.(16:47)
Source Isakowitz(1991)

2. Launch operations.

GROUND SEGMENT:
Ground Control Network(GCN):
Processing Stations:
Fixed: Large Processing Station(LPS)
Transportable: Simplified Processing Station(SPS)
Mobile: Mobile Ground System(MGS)

Ref.(18:5-1) Source: SMC/FMC

Personnel Manning:
Manpower requirements for DSP was 737 Ref.(24:1-228) with base support 14% of overhead Ref.(15:4-42)would be an additional 103 slots for a total of 840 personnel supporting the DSP program. This is shown only for representation purposes--it does not necessarily reflect today's authorized nor actual manning. For an in depth LCC cost estimate the manning should be captured and shown.

ATTACHMENT 8

Inflation Tutorial

The first thing that must be said about inflating cost figures is that you must use the most current OSD indices. You are directed to use OSD indices and you are not encouraged to build your own inflation table. You can get the most recent update by accessing the internet SAF/FMC home page by going to http://www/hq.AF.Mil/HqUSAF/FM/ and click on SAF/FMC, click on Air Force Inflation Home Page. You can reference AFI 65-503, Attachment 48 or you can call the OPR SAF/FMCE at DSN 227-9347 You can also research the AFSC Cost Estimating Handbook, chapters 4 and 5 to get an in-depth explanation of inflation. However, you only need the basic methodology not all the theory.

The methodology is basically simple and once you have the current indices, work only with the base year indices that you are converting all cost figures to—in our case everything was converted to base year 97. (See Figure 2) Then locate the proper cost/money category, i.e. RDT&E(3600), investment(3010, 3020, 3080), O&S(3400, 3500), and military construction(3300) and you divide the raw index number into the known constant year dollar figure to get the inflated figure. You will know for sure if you have the proper base year indices if the noted year—in our case 97— year reflects an entry of 1.000 across all cost categories. To convert from one constant year dollar to another base year dollar divide the constant year dollar by the raw inflation index number for that base year cost category.

There are raw indices and weighted indices but in this document we are not using then year dollars but only constant year dollars; therefore, we only need the raw inflation indices. All calculations in this document used raw inflation indices to convert one constant year dollar to another year—constant year dollar. However, in your cost estimate you may encounter then year dollars and then you would need the inflation decision rules that should be applied. These rules are given as follows:

1. To convert **BY$ to CY$, multiply** by a raw inflation index.
2. To convert **CY$ to BY$, divide** by a raw inflation index.
3. To convert **BY$ to TY$, multiply** BY$ by a weighted inflation index.
4. To convert **TY$ to BY$, divide** TY$ by a weighted inflation index.
5. To convert the BASE Year(BY) of a **set of raw inflation index numbers to a new Base Year, divide** each raw inflation index number by the raw index of the desired new Base Year.
6. To convert the Base Year(BY) of a **set of weighted inflation index numbers to a new Base Year, divide each weighted inflation index number** by the raw index number of the desired Base Year where both the raw index and the weighted index have the same Base Year.
7. Use **raw inflation index** numbers whenever you are working with dollars to be expended in a **one-year time frame.**
8. Use **weighted inflation index** numbers whenever your are working with dollars which will be expended over a **period of several years.**

As you can see that in this document we have only used rule number two because we were converting from some constant year dollar(CY$) to a base year dollar(BY$)—in this case to FY97—by dividing the CY$ by a raw inflation index(Base Year97).

FIGURE 2

OPR: SAF/FMCEE
DATE OF OSD INFLATION RATES FOR PERSONNEL : 7 JANUARY 1997
DATE OF OSD INFLATION RATES FOR NON-PERSONNEL : 7 JANUARY 1997
DATE OF SAF/FMC ISSUE : 9 JANUARY 1997

USAF RAW INFLATION INDICES
BASED ON OSD RAW INFLATION RATES
BASE YEAR FY 1997

	MILITARY COMPENSATION										
FISCAL YEAR	PAY BASE (3500)	OTHER EXPENSES (3500)	TOTAL (3500)	RETIRE-MENT (3500)	GENERAL SERVICE & WAGE BOARD PAY (3400)	OPERA-TIONS & MAIN-TENANCE: NON-PAY, NON-POL (3400)	RESEARCH, DEVELOP-MENT, TESTING, EVAL. (3600)	MILITARY CONSTRUC-TION (3300)	AIRCRAFT AND MISSILE PROCURE-MENT (3010/20)	OTHER PROCURE-MENT (3080)	FUEL
1949	0.084	0.143	0.090	0.142	0.077	0.153	0.156	0.153	0.143	0.155	0.164
1950	0.095	0.150	0.101	0.137	0.081	0.151	0.154	0.151	0.141	0.153	0.159
1951	0.100	0.161	0.103	0.220	0.080	0.161	0.164	0.160	0.150	0.163	0.174
1952	0.099	0.162	0.106	0.216	0.085	0.165	0.169	0.165	0.155	0.168	0.168
1953	0.106	0.163	0.112	0.219	0.088	0.168	0.171	0.168	0.157	0.170	0.171
1954	0.106	0.159	0.112	0.205	0.093	0.170	0.173	0.170	0.159	0.173	0.167
1955	0.108	0.164	0.114	0.217	0.098	0.173	0.176	0.173	0.161	0.175	0.178
1956	0.114	0.171	0.121	0.232	0.106	0.177	0.181	0.177	0.166	0.180	0.186
1957	0.111	0.178	0.119	0.241	0.110	0.184	0.188	0.184	0.172	0.187	0.200
1958	0.118	0.195	0.127	0.243	0.124	0.188	0.192	0.188	0.176	0.191	0.202
1959	0.126	0.198	0.134	0.260	0.132	0.192	0.196	0.192	0.179	0.194	0.207
1960	0.127	0.199	0.136	0.258	0.136	0.196	0.200	0.196	0.183	0.199	0.205
1961	0.128	0.202	0.138	0.257	0.147	0.198	0.202	0.198	0.185	0.201	0.210
1962	0.128	0.204	0.137	0.257	0.151	0.201	0.205	0.201	0.188	0.204	0.207
1963	0.129	0.204	0.138	0.255	0.156	0.204	0.208	0.204	0.191	0.207	0.208
1964	0.140	0.212	0.149	0.266	0.163	0.207	0.211	0.207	0.194	0.210	0.208
1965	0.146	0.220	0.155	0.270	0.173	0.211	0.215	0.211	0.197	0.214	0.211
1966	0.156	0.230	0.166	0.282	0.179	0.217	0.221	0.217	0.203	0.220	0.218
1967	0.164	0.246	0.176	0.293	0.187	0.224	0.228	0.224	0.209	0.227	0.226
1968	0.172	0.260	0.186	0.303	0.194	0.232	0.236	0.232	0.217	0.235	0.233
1969	0.186	0.265	0.198	0.319	0.206	0.243	0.247	0.243	0.227	0.246	0.241
1970	0.215	0.274	0.223	0.343	0.230	0.256	0.261	0.256	0.239	0.260	0.250
1971	0.233	0.287	0.240	0.379	0.250	0.269	0.274	0.269	0.251	0.273	0.262
1972	0.272	0.297	0.275	0.404	0.271	0.281	0.287	0.281	0.263	0.285	0.272
1973	0.305	0.311	0.306	0.429	0.287	0.294	0.300	0.294	0.275	0.298	0.283
1974	0.326	0.345	0.328	0.470	0.312	0.317	0.323	0.317	0.296	0.321	0.299
1975	0.347	0.365	0.349	0.537	0.338	0.351	0.358	0.351	0.328	0.356	0.345
1976	0.365	0.386	0.367	0.596	0.365	0.375	0.383	0.375	0.351	0.380	0.370
19TQ	0.375	0.396	0.377	0.613	0.381	0.388	0.395	0.387	0.362	0.393	0.385
1977	0.386	0.407	0.388	0.631	0.398	0.401	0.409	0.400	0.374	0.406	0.401
1978	0.412	0.429	0.414	0.679	0.429	0.432	0.436	0.428	0.400	0.434	0.429
1979	0.437	0.463	0.440	0.735	0.455	0.472	0.473	0.469	0.435	0.472	0.496
1980	0.468	0.498	0.471	0.824	0.486	0.517	0.517	0.517	0.477	0.517	0.896
1981	0.542	0.617	0.551	0.916	0.528	0.579	0.579	0.579	0.534	0.579	1.061
1982	0.617	0.655	0.621	0.976	0.558	0.632	0.632	0.632	0.585	0.632	1.044
1983	0.641	0.682	0.646	1.032	0.584	0.663	0.663	0.663	0.638	0.663	0.937
1984	0.661	0.704	0.665	1.068	0.602	0.689	0.689	0.689	0.689	0.689	0.851
1985	0.687	0.725	0.690	1.105	0.636	0.712	0.712	0.712	0.712	0.712	0.815
1986	0.715	0.742	0.717	1.111	0.642	0.732	0.732	0.732	0.732	0.732	0.636
1987	0.731	0.759	0.733	1.148	0.677	0.752	0.752	0.752	0.752	0.752	0.584
1988	0.747	0.779	0.750	1.150	0.738	0.774	0.774	0.774	0.774	0.774	0.488
1989	0.774	0.806	0.777	1.042	0.764	0.807	0.807	0.807	0.807	0.807	0.488
1990	0.803	0.830	0.805	1.081	0.793	0.839	0.839	0.839	0.839	0.839	0.578
1991	0.835	0.859	0.837	1.109	0.824	0.875	0.875	0.875	0.875	0.875	1.083
1992	0.869	0.890	0.871	1.139	0.858	0.900	0.900	0.900	0.900	0.900	0.922
1993	0.903	0.918	0.904	1.008	0.891	0.924	0.924	0.924	0.924	0.924	0.935
1994	0.926	0.935	0.927	1.022	0.921	0.942	0.942	0.942	0.942	0.942	1.067
1995	0.949	0.956	0.950	1.033	0.948	0.960	0.960	0.960	0.960	0.960	0.935
1996	0.972	0.975	0.973	0.981	0.972	0.979	0.979	0.979	0.979	0.979	0.987
1997	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

	MILITARY COMPENSATION										
FISCAL YEAR	PAY BASE (3500)	OTHER EXPENSES (3500)	TOTAL (3500)	RETIRE-MENT (3500)	GENERAL SERVICE & WAGE BOARD PAY (3400)	OPERA-TIONS & MAIN-TENANCE: NON-PAY, NON-POL (3400)	RESEARCH, DEVELOP-MENT, TESTING, EVAL. (3600)	MILITARY CONSTRUC-TION (3300)	AIRCRAFT AND MISSILE PROCURE-MENT (3010/20)	OTHER PROCURE-MENT (3080)	FUEL
1998	1.028	1.024	1.028	0.962	1.029	1.021	1.021	1.021	1.021	1.021	1.197
1999	1.059	1.050	1.058	0.981	1.052	1.042	1.042	1.042	1.042	1.042	1.144
2000	1.091	1.077	1.089	1.000	1.073	1.064	1.064	1.064	1.064	1.064	1.174
2001	1.123	1.104	1.122	1.020	1.094	1.087	1.087	1.087	1.087	1.087	1.205
2002	1.157	1.132	1.155	1.043	1.116	1.110	1.110	1.110	1.110	1.110	1.236
2003	1.192	1.161	1.189	1.067	1.138	1.133	1.133	1.133	1.133	1.133	1.268
2004	1.227	1.191	1.224	1.092	1.161	1.162	1.162	1.162	1.162	1.162	1.301
2005	1.264	1.221	1.261	1.117	1.184	1.192	1.192	1.192	1.192	1.192	1.335
2006	1.302	1.252	1.298	1.143	1.208	1.223	1.223	1.223	1.223	1.223	1.370
2007	1.341	1.284	1.336	1.169	1.232	1.255	1.255	1.255	1.255	1.255	1.405
2008	1.382	1.317	1.376	1.196	1.257	1.288	1.288	1.288	1.288	1.288	1.442
2009	1.423	1.351	1.417	1.223	1.282	1.321	1.321	1.321	1.321	1.321	1.479
2010	1.466	1.385	1.459	1.252	1.307	1.356	1.356	1.356	1.356	1.356	1.518
2011	1.510	1.420	1.502	1.280	1.334	1.391	1.391	1.391	1.391	1.391	1.557
2012	1.555	1.457	1.546	1.310	1.360	1.427	1.427	1.427	1.427	1.427	1.598
2013	1.602	1.494	1.592	1.340	1.387	1.464	1.464	1.464	1.464	1.464	1.639
2014	1.650	1.532	1.639	1.371	1.415	1.502	1.502	1.502	1.502	1.502	1.682
2015	1.699	1.571	1.688	1.402	1.444	1.541	1.541	1.541	1.541	1.541	1.725
2016	1.750	1.611	1.738	1.434	1.472	1.582	1.582	1.582	1.582	1.582	1.770
2017	1.803	1.652	1.789	1.467	1.502	1.623	1.623	1.623	1.623	1.623	1.816
2018	1.857	1.694	1.842	1.501	1.532	1.665	1.665	1.665	1.665	1.665	1.864
2019	1.912	1.737	1.897	1.536	1.563	1.708	1.708	1.708	1.708	1.708	1.912
2020	1.970	1.782	1.953	1.571	1.594	1.753	1.753	1.753	1.753	1.753	1.962
2021	2.029	1.827	2.011	1.607	1.626	1.798	1.798	1.798	1.798	1.798	2.013
2022	2.090	1.874	2.071	1.644	1.658	1.845	1.845	1.845	1.845	1.845	2.065
2023	2.152	1.921	2.132	1.682	1.691	1.893	1.893	1.893	1.893	1.893	2.119
2024	2.217	1.970	2.195	1.720	1.725	1.942	1.942	1.942	1.942	1.942	2.174
2025	2.283	2.021	2.260	1.760	1.760	1.992	1.992	1.992	1.992	1.992	2.230

NOTES:

TABLE COLUMN	CATEGORY	DEFINITION
2	PAY BASE	BASIC PAY, REENLISTMENT BONUSES, SEPARATION PAYMENTS, FICA, DEATH GRATUITIES, CONTINUATION PAY FOR PHYSICIANS AND DENTISTS, BAQ, AND SEVERAL CATEGORIES OF SUBSISTENCE PAY
3	OTHER EXPENSES	INCENTIVE PAY, PROFICIENCY PAY, INTEREST ON SAVINGS, FLIGHT DECK PAY, OPTOMETRIST PAY, ENLISTMENT BONUSES, HOSTILE FIRE PAY, CLOTHING ALLOWANCE, SUBSISTENCE-IN-KIND, FAMILY SEPARATION PAY, STATION ALLOWANCE OVERSEAS, PCS, AND SEVERAL OTHER ITEMS
4	TOTAL	AN APPROPRIATE WEIGHTING OF COLUMNS 2 & 3
5	RETIREMENT	MILITARY RETIREMENT PAY
6	CIV PAY	PAY FOR GS, WAGE BOARD, AND FOREIGN NATIONAL DIRECT AND INDIRECT HIRES

TABLE USE:

RAW INDICES ARE USED TO CONVERT CONSTANT DOLLARS IN ONE YEAR TO CONSTANT DOLLARS IN ANOTHER YEAR.

USE WEIGHTED INDICES TO CONVERT CONSTANT TO THEN YEAR DOLLARS, AND VICE VERSA.

ATTACHMENT 9

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